Osteochondritis Dissecans

LOOSE BODIES IN JOINTS

ETIOLOGY, PATHOLOGY TREATMENT

BY

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E & S LIVINGSTONE LTD
EDINBURGH AND LONDON
1960

Printed in Great Britain

PREFACE

MY interest in osteochondritis dissecans began with *Injuries of the Knee Joint* It developed with the pursuit of what could not always be explained on a mechanical basis Here was a fascinating lesion with unsolved problems of etiology pathology and treatment

In this subject the first of many difficulties is the definition of what you are talking about immediately thereafter the relationship to the very conditions from which it has just been differentiated Such is the mysterious condition first treated by Ambrose Paré in 1558 the source first recognised by Alexander Munro in 1738 the pathology first described by Sir James Paget in 1870 and first named osteochondritis dissecans by Franz König in 1887

Osteochondritis dissecans as the descriptive title it is intended to be has little to commend it. But it is a name hallowed by more than time The temptation to increase the current confusion by adding a new one has not been difficult to resist

Neither in Part I nor Part II have the individual joints been approached from the same angle This may seem untidy in the administrative sense but has avoided some repetition in a lesion of similar characteristics no matter where the location but the entire Part must be read to gain the impression it is intended to convey No claim is made to have solved an age-old problem only that study of the three hundred cases recorded has permitted comparisons to be made and conclusions to be drawn which would not otherwise be possible

I acknowledge with gratitude the help of my colleagues of the Orthopaedic Service of the Eastern Region of Scotland Mr J Hutchison Mr I D Sutherland Mr G Murdoch Mr R. D Muckart Mr G L Clark Mr C S Campbell, Mr F H Moore (now of St Mary's Orthopaedic Hospital Cork Eire) and the present Senior Registrars Mr I M Stewart and Mr D M Caird who by referring their cases made possible the accumulation of the material It will be evident that this work has been made possible only by their interest and active co-operation To Dr W W Park of the Pathology Department of the University of St. Andrews I am indebted for the production and interpretation of the sections and the microphotographs

There are many others who have helped me and to whom I am grateful I would mention in particular Miss H M Lunan Secretary to the Department

of Orthopaedic Surgery University of St. Andrews Miss O Thom Secre to the Orthopaedic Department, Royal Infirmary Dundee Mrs Jack Hin recently Secretary to the Orthopaedic Department Royal Infirmary Dund Mr R G Donovan Photographic Technician Department of Orthopa Surgery University of St. Andrews who was concerned with the prepara of many of the illustrations and Mr Peter Fraser Chief Technician of Orthopaedic Workshop Bridge of Earn Hospital Perthshire who responsible for the development of the instruments

My special thanks are due once again for the assistance I have recei from Mr Charles Macmillan and Mr James Parker of Messrs E. & Livingstone Ltd.

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Dundee 1960

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PART 1

ETIOLOGY AND PATHOLOGY

Section I GENERAL

CHAPTER I

INTRODUCTION

IN the four centuries since the original arthrotomy of the knee the etiology of loose bodies which appear in joints thought to be otherwise normal has occupied the interest of many of our distinguished forebears It seems unlikely that a simple explanation of the phenomenon was somehow overlooked. Into the literature of recent years has crept the implication if not the direct statement that the condition we call osteochondritis dissecans is not an entity but a number of things. If there is a measure of agreement it is the part played by trauma in the production of the lesion But few believe it is the whole story Most seek additional constitutional factors which have defied definition.

It is attractive to postulate two or more forms of a disease It permits an explanation of what does not fit the particular theory we hold But it is clear that the condition encountered in a boy of fifteen is not the same, despite the radiological appearances as that which may affect the knee joint of an adult for the first time at twenty-five. Equally certain is it that the condition seen in the medial and lateral femoral condyles of one or both knees at the age of ten is not the same as the lesion of similar appearance seen in the adult. Further if the traumatic theory is to be accepted it is necessary to differentiate all three conditions from, or relate them to osteochondral fractures.

It is proposed to show that each of these lesions, of similar radiological appearance, is a distinct pathological entity capable of definition

1 The lesion seen at the age of say ten is an
ANOMALY OF OSSIFICATION;

2 The lesion seen at the age of fifteen is
JUVENILE OSTEOCHONDRITIS DISSECANS;

3 The lesion arising for the first time in the adult is
ADULT OSTEOCHONDRITIS DISSECANS;

4 Certain other lesions are
TANGENTIAL OSTEOCHONDRAL FRACTURES.

It is proposed to show that all four are related in the etiology of osteochondritis dissecans

RADIOLOGY AND PATHOLOGICAL ANATOMY LIMITATIONS OF RADIOLOGY

Osteochondritis dissecans is a condition determined by radiological examination. In an investigation into the cause and nature of the disease reference must be made to radiographs. It is characteristic of the condition in general that the many stages in the pathological anatomy which exist before the last isthmus of articular cartilage gives way and the loose body is cast into the joint are represented by not dissimilar radiological appearances. The problem is even more complicated reference has been made already to the possible confusion with anomalies of ossification and with tangential osteochondral fractures

In a straight radiograph of a joint what is seen is an outline and an outline only of the bone components The most important element, articular cartilage, is not depicted. This explains the astonishment expressed by the uninitiated when the interior of a knee joint the subject of rheumatoid arthritis is exposed at operation the pathological anatomy seems to bear so little relationship to the radiographs. Reference will be made throughout this work but particularly in relation to Freiberg s infraction where the lesion involves the entire joint, how much further the pathology is advanced than the radiographs indicate indeed, how far the pathology is advanced before there is any hint of abnormality The earliest stage of Perthes disease for example, is not an increase in the density of the femoral epiphysis but an increase in joint space. It indicates thickening of articular cartilage enveloping ischaemic bone. The advent of sclerosis comes later But it is not a relative increase of density it is actual when compared with the normal side

In Freiberg s infraction or in Perthes disease the head is dead, in whole or in part, long before there is an increase in density The time probably varies but it is well known that it may take as long as two years for aseptic necrosis to become a radiological entity in dislocation of the hip or fracture of the neck of the femur If ischaemia is complete actual increase in density takes place only as a result of calcification that is extraction of radio-opaque minerals from tissue fluids by perfusion Similar circumstances obtain in all the aseptic necroses or juvenile osteochondroses and in the bony element of the osteochondral loose body in osteochondritis dissecans. The practical importance of such observations does not require to be stressed

The confusion in definition etiology pathology and treatment which exists throughout the voluminous literature devoted to the study of osteochondritis dissecans is based on the fallacy of describing pathological anatomy in terms of radiographic appearances In the radiographs of an osteochondritis dissecans-like lesion it will be accepted that the zone of sclerosis can be

interpreted in terms of ischaemia But what of the zone of rarefaction? It could be true rarefaction of bone but uncalcified cartilage fibrous tissue and most important of all an actual space, all have a similar appearance It is little wonder so much conflict of opinion on almost every aspect of the disease exists.

OSSIFICATION OF LOWER FEMORAL EPIPHYSIS

The frequency with which irregularities of ossification in various forms are encountered at the periphery of the epiphysis of the femur is a feature of the radiology of the knee joint in children Interest in the subject was stimulated by the description by Ribbing (1937) of radiological changes resembling osteochondritis dissecans in the joints of several members of a family suffering from a condition which he named Hereditary Multiple Epiphyseal Disturbance In the course of investigation an osteochondritis dissecans-like lesion was noted to develop in the lower femoral epiphysis of one of the family from an apparent accessory centre of ossification In a subsequent study (Ribbing 1944) of some 400 children aged 1 to 10 years equally divided as regards sex 29 per cent of the boys were found to exhibit accessory centres in the lower femoral epiphyses and were affected three to four times more often than girls The irregularities were seen earlier and disappeared earlier in girls who were seldom affected after the age of four In boys the changes remained to about the age of ten Sontag and Pyle (1941) undertaking a longitudinal study of 220 children from the age of one month to the age of six years found irregularity of outline to be an almost universal finding. Novotny (1951) examining a group of twenty boys from 3 to 11 years old and fifteen girls from 2 to 8 years old found osseous nuclei in fourteen of the twenty boys but in only two of the girls. He explained the rarity of irregularities of ossification in girls by the fact that most of the group were over 4 years old.

In an attempt to determine the frequency and form of irregular ossification Caffey Madell Royer and Morales (1958) obtained radiographs in the form of antero-posterior lateral and tunnel (Holmblad 1937) projections of the knees of 147 children between the ages of three and thirteen all known to be free of clinical abnormality in the knee joints

To assess the findings the irregularities were divided into three groups The classification is arbitrary more than one type can be found in the same joint. It is recorded and will be used as it forms some basis for reference and comparison

Type I. There are varying degrees of roughening of the margins occasionally small foci of calcification immediately beyond the roughened edge of the main centre (Figs. **1**, **1** **1**, **2** **1**, 3 and **1**, 5)

Type II There are larger localised marginal irregularities in the form of indentations (Fig. 1, 4)

Type III. There are marginal irregularities of the same type as Type II except that an independent island of bone is seen within the indentation (Fig 1, 3)



Fig. 1 1 Fig. 1 2

Anomalies of Ossification

Fig. 1 1 Knee joint of boy aged 9 showing irregularity and separate centre of ossification outside the roughened outline of the main mass (Type I). Fig. 1, 2 Knee joint of boy aged 6 showing marked irregularity of femoral condyle (Type I). Note also irregularity and apparent multipolar ossification of patella

The outstanding feature of the investigation was the finding that marginal irregularities of the epiphyses were more common than those of regular outline They were present in 66 per cent of the boys and 44 per cent of the girls. In 44 per cent of the total both femoral condyles were affected The lateral condyle only was involved in 44 per cent the medial condyle only in 12 per cent. *The changes seen were frequently bilateral* but were not always symmetrical



Fig. 1 3



Fig. 1 4

Anomalies of Ossification

Knee joints of boy aged 11 showing asymmetrical anomalies Types I II and III

Fig. 1, 3 Right. Anomaly in the medial condyle in the form of indentation enclosing island of bone separate from main mass (Type III) Anomaly in lateral condyle in form of irregularity of outline (Type I) Fig. 1 4 Left. Anomaly in the medial condyle in the form of indentation surrounded by band of increased density (Type II) Lateral condyle appears normal

Fig. 1 5 Anomaly of ossification, Type III in boy aged 5 He is a younger brother of R S., aged 12 (K157), and A S aged 14 (K162, Table III), both of whom developed osteochondritis dissecans lesions.



Fig. 1 5

NATURE OF ANOMALIES OF OSSIFICATION

The studies quoted differ in their findings and in any event, without some standard of irregularity if such were possible are not strictly comparable. If any general conclusion can be drawn it would appear that irregularities of ossification, of Type I at least, are a normal variant in the first half of the first decade Such irregularities are not confined to the knee but appear to be most common in the knee. It is the joint most subject to trauma minor and otherwise in childhood and as a result most frequently demands radiological examination The likely explanation however is the size of the epiphysis of the femur and the rapidity of growth at this site The zones of proliferating cartilage and provisional calcification are considerably deeper than in a slowly growing epiphysis. It seems evident that when growth is extremely rapid as it is at the lower end of the femur the orderly process of cartilage prolifera tion and provisional calcification can appear outside the radiographic image of the main mass of calcified cartilage during periods of active growth. When the invading osteoblasts replace the provisionally calcified cartilage by bone trabeculae the regular outline is re-established It is probably a matter of the adjustment of blood supply to the needs of bone growth If this explanation is correct, it seems not unlikely that the transition from smooth to irregular outline could be repeated during periods of accelerated growth.

There is a clinical analogy to the radiographic picture It is well known that in the development of a child growth does not take place evenly over the years There are periods when it takes place very rapidly and it is at such times that various orthopaedic troubles are experienced. When a long bone grows rapidly for example there is a lapse in time before the associated muscles develop in proportion to the length of the levers they control It is at these times that postural defects are evident. In certain individuals the situation recurs every time there is sudden acceleration of skeletal growth It is the basis of the lay assessment of the situation when it is said that " the boy is outgrowing his own strength.

It is probable that a similar relationship occurs between the cartilaginous and bony elements of joints in young people. At certain stages of development there seems to be a disproportionately large amount of cartilage It appears to occur in the early years of the first half of the second decade and is particularly noticeable in the knee joint.

If an acceptable explanation has been offered of the radiographic appear ances of irregularities of ossification which could be classified as Type I the explanation of the radiographic appearances of Types II and III is less easy The difference between the two may be merely a matter of degree or even of the age at which the radiograph was taken Type II must be *presumed to*

represent a localised segment within the epiphysis in which provisional calcification is retarded How this occurs is a matter for conjecture But the fact that the defect is surrounded by a zone of increased density suggests a possible local deficiency of blood supply On this basis Type III represents a focus of ossification within the area of the defect but separate from the main mass In the series studied by Caffey Madell Royer and Morales Type II and III defects were present in 30 per cent of all male and 17 per cent of all female children

The patients investigated by Sontag and Pyle covered the period 0 to 6 years those of Caffey Madell Royer and Morales the period 3 to 13 years. If irregularities were almost universal in the earlier series it is evident from the figures of the later series that irregularities of ossification of all three types decrease in frequency with increasing age. In the early years of the first half of the second decade depending probably upon bone age, they should have disappeared. This observation is of some practical importance in the radiographic differential diagnosis of osteochondritis dissecans.

There were several instances in the early years of this series where anomalies of ossification consisting of small circumscribed pits in the femoral condyle (Type II) were discovered in the course of investigation of some other condition principally recurrent subluxation of the patella in the 10-15 year old age group They were regarded at that time as atypical varieties of osteochondritis dissecans and the lesions being small were kept under observation in view of the necessity for treatment of the major condition It was noted with interest that when the treatment of the major condition was completed, whether it consisted of rest, immobilisation, or operation followed by immobilisation the osteochondritis dissecans-like condition had healed Such lesions came to be known as the kind that heals "

IRREGULARITY OF OSSIFICATION AT OTHER SITES

Irregularity of ossification at other sites was a common feature of cases showing anomalies of ossification at the lower femoral epiphysis whether they disappeared spontaneously or proceeded to pathological changes Such irregularities as osteochondritis or multipolar ossification of the patella (as opposed to Sinding Larsen Johannson traction epiphysitis) multipolar ossification at the lower end of the humerus, etc have characteristic radiological appearances and are unlikely to be mistaken for osteochondritis dissecans They do not confuse the issue except in so far as the frequency and normality of such appearances is unknown

Anomalies comparable with those described in the knee were not observed in the head of femur capitellum or head of radius talus or metatarsal head in this series.

Routine systematic radiographic examination of other joints was not practised in those cases in which an anomaly of ossification at the lower femoral epiphysis was discovered not even when the anomaly proceeded to pathological changes The patella changes were an incidental finding in radiographs of the knee the elbow joint chosen out of interest as a frequent site of osteochondritis dissecans. No case exhibiting incidental changes in the lateral condyle or elsewhere at the lower end of the humerus proceeded, as far as is known to pathological changes.

It is clear from the variety of appearances in radiographs particularly of the knee joint at the period under consideration, that the border-line between the normal and the abnormal is narrow Is the appearance of a small separate ossific centre normal? But a joint showing such a centre or centres does not necessarily proceed to osteochondritis dissecans.

A feature of the series was the incidental finding of anomalies of ossification in the knee joints of boys brought up with an acute injury It is probably impossible to say with certainty what is normal and what is abnormal without investigating a statistically significant number of knees of boys beginning, say at the age of eight and taking radiographs at three-monthly intervals until the age of say fifteen. It would be of the utmost value to follow cases in which apparently abnormal features are discovered to see what proportion develop pathological changes and the circumstances which determine the changes.

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CHAPTER 2

JUVENILE OSTEOCHONDRITIS DISSECANS

DEFINITION Juvenile osteochondritis dissecans is the variety which is encountered in the knee joint in particular towards the middle of the second decade and which originates in an anomaly of ossification or abnormality of endocrine function

It will be shown that every case of osteochondritis dissecans occurring at this period does not of necessity arise in such causes The agents which produce the Adult varieties operate at all ages

RELATIONSHIP OF ANOMALIES OF OSSIFICATION TO JUVENILE OSTEOCHONDRITIS DISSECANS

In the search for the elusive factors in the etiology of Juvenile osteochondritis dissecans the theory of an association with anomalies of ossification is not new It was probably Troell (1914) who first suggested the possibility of a superficial accessory nucleus at the epiphysis of the medial femoral condyle as a cause There are numerous references in the literature to the all-embracing doctrine of Lehmann (1922) of the constitutionally weak epiphysis Reference has been made already to Ribbing s (1937) observation of osteochondritis dissecans-like lesions developing in the condition he named Hereditary Multiple Epiphyseal Disturbance Lacroix (1941) has stated that the histological structure of loose bodies indicates an irregularity of ossification

In the course of this series the transition from what was considered to be an anomaly of ossification to what was considered to be Juvenile osteochondritis dissecans was observed on many occasions The evidence is not based on radiological findings, which indicate the change of status only at a late stage but on consideration of the clinical features of the cases and direct observation of the pathological anatomy in the course of operative treatment. It is proposed to develop the theories and record the observations on which the association is based

THE COMMON SITE OF ANOMALIES OF OSSIFICATION IN CHILDHOOD, NAMELY, THE CENTRE OF MEDIAL FEMORAL CONDYLE, CORRESPONDS TO THE CLASSICAL SITE FOR OSTEOCHONDRITIS DISSECANS IN MATURITY

Ribbing (1944) in the course of the investigation referred to on page 5 demonstrated that if the sites of accessory nuclei of ossification in the child are projected on to the adult femur those centres situated most superficially that is to say those occurring latest in the first half of the second decade are nearest to the classical site (Figs 2, 1 and 2, 2) It will be shown later that

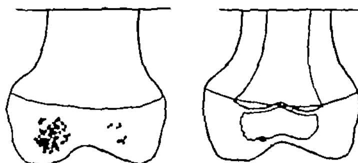


Fig. 2, 1 Fig. 2, 2

Relationship of Anomalies of Ossification to Osteochondritis Dissecans

Fig. 2, 1 Diagrammatic representation of sites of accessory nuclei of ossification in children projected on to adult femur (after Ribbing) Fig 2, 2 Outline of femoral epiphysis of child projected on to lower end of femur in adult showing accessory nucleus of ossification in child as lesion at classical site in adult (after Ribbing).

this site can be demonstrated to be vulnerable to trauma Thus anomalies of ossification arising late or persisting, are those most liable to transition to the pathological state. This corresponds to the phenomenon frequently observed in this series, but unproved statistically that anomalies of ossification in the lateral as opposed to the medial condyle tend to disappear spontaneously

ISCHAEMIA

Ischaemia plays a large part in human pathology Angina pectoris and thromboangiitis obliterans are familiar examples of ischaemia of muscle in relative degree. In childhood the only common manifestations occur in bone and we must accept the concept of relative ischaemia in bone just as we accept the concept of relative ischaemia in muscle.

The basic pathology of osteochondritis dissecans, whether of the Juvenile or Adult variety is local ischaemia relative or absolute. The manifestations

differ in the various joints Anomalies of ossification in the form of accessory centres for example are common in the knee, uncommon in the hip or metatarsal head and it might seem that deficiency of blood supply when it does occur takes a local form in the one and total form in the others It is



FIG 2, 3



FIG 2, 4

Anomalies of Ossification

Anomalies of ossification which persist in adult life are seen in the bipartite and tripartite forms of the patella. The accessory centres are located at the supra lateral angle



FIG. 2, 5

possible that for mechanico-anatomical reasons in addition to those of blood supply the hip as opposed to the knee is subject to total as opposed to local lesions. Just as there is no condition in the knee comparable with Perthes disease so there is no common lesion in the hip comparable with osteochondritis dissecans in the knee

Osteogenesis necessitates a blood supply greater than that required for life or for osteoporosis. The cartilage of an epiphysis requires a liberal blood supply for conversion to bone. The weight-bearing articular cartilage demands total ischaemia The underlying supporting bone requires a blood supply In the changes occurring in the growing child there are periods, different in each epiphysis when there is relative ischaemia. The blood supply of the part is inadequate to the strains placed upon it. It is at such times that the epiphysis is vulnerable to injury either in whole (Perthes disease Freiberg s infraction) or in part (osteochondritis dissecans) The possible relationship between anomalies of ossification and blood supply is seen in the patella where accessory centres, which persist in adult life in the familiar bi and tri partite forms of the bone are common findings in radiographs of the knee (Figs. 2, 3 2, 4 and 2, 5) It is of significance that such anomalies should be located at the supra lateral angle where from clinical experience of the outcome of injury some doubt exists on the adequacy of the blood supply

THE TRANSITION FROM ANOMALY OF OSSIFICATION TO PATHOLOGICAL PROCESS IS DUE TO INTERRUPTION OF BLOOD SUPPLY

Anomalies of ossification no matter what view is held of their relationship to normal usually disappear spontaneously but not always. What determines the transition from a variant of ossification to a pathological process is the point at issue. The advent of an accessory nucleus of ossification is determined by the presence of a blood supply but, separated from the adjacent cancellous bone of the epiphysis by hyaline cartilage, it must be precarious In addition the very production of accessory centres of ossification is probably an expression of a process of exceptionally rapid growth as such they are vulnerable.

Attention has been directed to the fallacy of the interpretation of radiographs in terms of pathological anatomy and the erroneous conclusions which have been drawn as a result. Nevertheless, from what is known of the nature of such conditions as Perthes disease Keinbock s disease and even of avascular necrosis of the head of the femur following fracture, the basic pathology of certain anomalies of ossification at the precursor stage, as determined by the appearance of the radiographs, clearly involves a local alteration in the blood supply of epiphyseal bone. The rapid return to radiological normal which follows the simple procedure of drilling the area favours this view

It appears that in some way the blood supply to the accessory nucleus has been interrupted The closer the nucleus comes to the surface or towards the

classical site as age advances to maturity the greater will be the vulnerability to injury It is no longer cushioned by a thick layer of flexible cartilage which disperses the effects of weight-bearing But when the nucleus approaches the surface it is the very flexibility of cartilage which determines the transition to the pathological process movement within the cartilagenous layer between accessory nucleus and parent epiphysis interrupts the blood supply to the ossicle.

It appears therefore that the relationship of anomalies of ossification to osteochondritis dissecans is simply that anomalies of ossification are a manifestation of local deficiency of blood supply in epiphyseal bone occurring at the end of the first decade They are most common at the lower femoral epiphysis if it is only for the reason that the knee of all joints is the one most affected by trauma and from the viewpoint of blood supply is the joint with the largest mass of bone distal to an epiphyseal plate. It is a pressure epiphysis not only by reason of the attachment of the powerful quadriceps to the head of the tibia but from the simple direct pressure of body weight. If by chance the bone affected by the temporary vascular deficiency is subjected to constantly repeated trauma a fracture, probably of the nature of a fatigue fracture takes place Thus osteochondritis dissecans superimposed on an anomaly of ossification is no different than osteochondritis dissecans occurring *de novo* whether it is in the knee or in the head of the second metatarsal In each instance there exists a local vascular deficiency leading to vulnerability to injury and eventually to a form of fatigue fracture and the same stress which interferes with the blood supply is responsible for the eventual fracture Further than this in establishing the nature of the lesion in the early stages, it is not possible to go

It is possible from the pattern of symptoms and from the findings at operation to draw certain inferences regarding the nature of the later developments. We know that the early changes are reversible and that spontaneous healing occurs. We know also that certain cases for reasons which will be described, proceed to what we choose to call osteochondritis dissecans We know that symptomless cases kept under observation in the hope of spontaneous healing can suddenly develop giving-way incidents indicating instability of a weight-bearing area. It can be assumed that the change can be due only to the development of the fracture or horizontal cleavage lesion in the surface layers of the bone (Figs. 2, 6 and 2, 7 Figs 2, 8 and 2, 9)

In order to demonstrate the contrast which exists between anomalies of ossification and Juvenile osteochondritis dissecans and yet the close relationship to show the difficulty of distinguishing one from the other and to

explain the reason why so many erroneous conclusions have been drawn, one case in particular is quoted

The boy (J H K85 Table III) was first seen at the age of 10 with a history that one year previously he had sustained a fracture of the tibial spine on the Left side This had been treated by immobilisation in plaster and had healed with some deformity indicating lengthening of the anterior cruciate ligament. The



FIG. 2, 6A FIG. 2, 6 FIG. 2, 7

Anomaly of Ossification to Osteochondritis Dissecans

The transition has occurred. Antero-posterior radiograph shows squaring of medial condyle from loss of support of articular cartilage (Fig. 2, 6). Lateral radiograph shows lesion more distinctly but does not indicate the change of status (Fig. 2, 7) (J M., male, aged 13 K134 Table III)

surgeon who saw him made a diagnosis of a torn medial meniscus. When the new radiographs became available it was evident that he had an anomaly of ossification (Type II Fig 1 3) But the radiological findings could not explain his symptoms and at operation a medial meniscus the subject of both longitudinal and horizontal cleavage tears was found This meniscus lesion clearly dated back to the injury when the tibial spine was fractured or resulted from the subsequent laxity of the ligaments. The point of particular significance, and showing that anomalies of ossification are not related to injury is that when a radiograph of the Right knee

was obtained, exactly the same condition was found in the medial femoral condyle (Type III Fig 1, 4) Thus the injury was unilateral but the anomalies of ossification bilateral and therefore unrelated

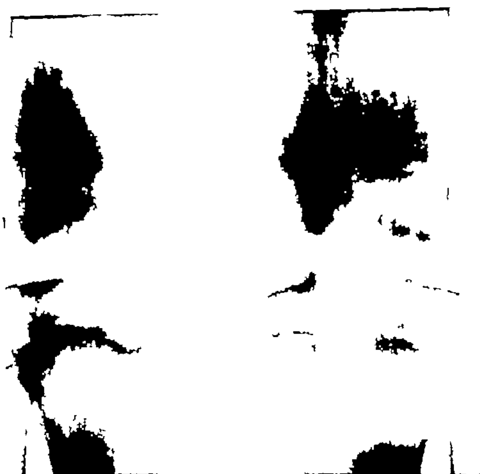


FIG. 2, 8 FIG. 2, 9

Anomaly of Ossification and Osteochondritis Dissecans

Multiple-layer single-exposure tomograph of knee joints (R. R., male, aged 12, K131 Table III) Lesion in lateral condyle on Left side is anomaly of ossification. Lesion in lateral condyle on Right side is osteochondritis dissecans. Note loss of rounded contour of condyle from absorption of cancellous tissue supporting articular cartilage (Fig. 2, 9)

The subsequent history demonstrates why so many conflicting opinions have existed regarding treatment in the past one month following the meniscectomy on the Left side the surgeon elected to drill the lesion on the Right side. At operation, the lesion could not be visualised but is known to have been located and drilled The lesion on the Left side received no treatment. Thus bilateral symmetrical anomalies of ossification of Type III were drilled on one side and received no treatment on the other Five months later radiographs showed no trace of the lesion on either side.

In direct contradistinction is quoted

the case of P K (K130 Table III) a girl first seen at the age of 10·5 with mild

symptoms in both knees but no radiological abnormality Six months later radiological changes were present in both medial femoral condyles and, considered to be anomalies of ossification, were kept under observation. Three months later giving way incidents occurred in relation to the Right knee. These symptoms suggested that pathological changes had been superimposed on the anomaly and that the weight bearing surface was no longer stable No symptoms of significance, such as giving way were present on the Left side It was decided therefore to carry out a drilling operation on the Right side and to treat the Left side expectantly and this decision seemed suitable to the circumstances because there were domestic reasons why the child should remain in hospital during treatment. The opportunity thus arose to treat the Right side in which Juvenile osteochondritis dissecans was superimposed on an anomaly of ossification by operation and the Left side, with similar radiological changes, by bed rest. At the end of four months the Right side had healed but on the side treated by rest there was no change At this stage it was felt there was little alternative but to permit the child to return to weight-bearing and keep the Left, the unhealed side, under observation Within three months however the mother brought the child back with the complaint that, while the Right side was symptomless, the Left side was producing giving way incidents There was thus no alternative, in view of the success of the original operation to a drilling procedure on the Left side. The second knee like the first, healed clinically and radiologically in three months time.

THE CREATION OF AN ACTUAL SPACE OR FRACTURE WITHIN THE BONE, WHICH IS CHARACTERISTIC OF EITHER JUVENILE OR ADULT VARIETIES, WHETHER IT IS CLOSED OR COMMUNICATES WITH THE INTERIOR OF THE JOINT CAN OCCUR ONLY THROUGH THE AGENCY OF TRAUMA

It is not difficult to explain the existence of a fracture or space within the substance of cancellous tissue when the lesion is located at the classical site on the lateral margin of the medial femoral condyle provided it is accepted that contact with the tibial spine is possible. It will be shown in a later section that such contact occurs and that a fracture of the nature of an internal tangential osteochondral fracture is produced as a result. It is more difficult to explain the presence of a fracture within the substance of cancellous tissue in the centre of the medial femoral condyle when the space, and it is an actual space neither communicates with the intercondylar notch nor breaks the surface of the overlying articular cartilage

Horizontal cleavage in fibrocartilage. In the surgical pathology of the menisci of the knee joint it can be shown that the horizontal split, or horizontal cleavage lesion, is the basic tear rather than the vertical split, longitudinal or bucket handle tear as is generally accepted (author unpublished work)

The most widely known lesion of the horizontal cleavage type is that which affects the lateral meniscus and called the parrot-beak tear (Smillie 1946) It is frequently associated with cystic degeneration That a horizontal cleavage lesion could exist within the substance of a meniscus without communication with the surface of the structure was first described in the congenital disc (Smillie 1948) and the diagram used on that occasion is reproduced to illustrate the point at issue (Fig. 2, 10) The lesion occurs when movement, instead of taking place between meniscus and femur or meniscus and tibia takes place within the substance of the structure so that the superior surface moves on the inferior surface The common circumstances in which this may occur are

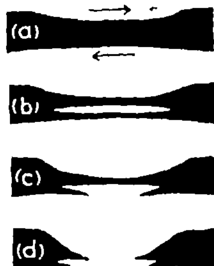


FIG 2, 10
Horizontal Cleavage
The original diagrammatic representation of the stages of horizontal cleavage in the congenital discoid meniscus (a) superior and inferior surfaces shift in relation to one another (b) line of cleavage develops (c) inferior surface wears away and (d) wearing of both surfaces results in a central hole. (a) and (b) have a counterpart in the production of the lesion of osteochondritis dissecans

1 **The meniscus is prevented from following the movements of the femur** This is the explanation of the association between the parrot-beak tear of the lateral meniscus and cystic degeneration cystic degeneration fixes the periphery and thus restricts mobility

2. **The meniscus is thick.** This is the explanation which applies to the congenital disc movement occurs between the surfaces

3 **The meniscus is the subject of degenerative changes.** This is the explanation of the common lesion of the posterior segment of the medial meniscus encountered in the fourth and fifth decades in the absence of a history of trauma

The blood supply of a meniscus is limited to the convex border where a fold of synovial membrane extends inwards for a short distance over the periphery on both the superior and inferior surfaces The nutrition of the substance of the fibrocartilage is precarious. The internal structure may and does break down with nothing more than the trauma of normal weight bearing.

Each of these circumstances has a counterpart in the production of a similar lesion in bone.

Horizontal cleavage in bone. It will be shown in a later section that in general the separation of the fragment in osteochondritis dissecans takes place not between articular cartilage and bone but in the superficial layers of the bone It is probable that in the development of Juvenile osteochondritis from

an anomaly of ossification the bony element of any potential loose body is relatively small if it is only for the reason that the accessory nucleus is small In the transition from anomaly of ossification to osteochondritis dissecans it seems not unlikely that the horizontal cleavage develops in a similar manner and for similar reasons to those described in the menisci In the early stages the hard accessory bone nucleus, located as it is in flexible cartilage, is subjected to trauma inflicted upon it by weight-bearing but in particular by the screw home movement of the joint. It may be supplied by an end artery the earliest stage may be impairment of blood supply Movement starts to take place between bony nucleus and parent bone, possibly within tissue of impaired blood supply in exactly the same way as movement starts to take place between superior and inferior surface of a degenerate meniscus. Just as destruction of tissue occurs within the fibrocartilage leaving a closed space, so a similar lesion develops in the epiphysis It differs only from the meniscus lesion in occurring within growing tissue. Thus a lesion which developed originally in cartilage might, in the course of time, be located in bone.

The horizontal cleavage lesion whether it is located in fibrocartilage as it is in the case of the meniscus or in the superficial layers of bone as it is in *relation to articular cartilage is confined to joints in which rotation is a* salient feature of the mechanism It is the all important screw-home movement which determines the lesion in the knee joint whether it is located in fibrocartilage or bone It will be shown later that a lesion of similar etiology occurs in the rotating head of the radius if it comes in contact with the capitellum

TRAUMA IS THE FACTOR IN THE LOCALISATION OF THE LESION

It is not unlikely that once an anomaly of ossification and the vascular changes implied have affected the bone of a femoral condyle the constantly repeated trauma inflicted by the action of walking is liable to produce a fatigue fracture Thus the original lesion turns into osteochondritis dissecans with all the possibilities of the eventual separation of loose bodies into the joint. But the liability of an anomaly of ossification to turn into osteochondritis dissecans probably depends on the vulnerability of the site affected It is greater in the medial than in the lateral condyle greatest of all at the classical site But the fact that the lesion occurs at the classical site does not mean that spontaneous healing will not occur or that it must invariably proceed to osteochondritis dissecans with the separation of loose bodies. As in osteochondritis dissecans arising *de novo* it probably depends on the

anatomical conformation of the particular knee joint and the trauma to which the classical site is subjected. The influence for healing or progression to osteochondritis dissecans of the attachment of the posterior cruciate ligament, is unknown

The vulnerability of the medial femoral condyle by comparison with the lateral and of the etiology of Juvenile osteochondritis dissecans in general is illustrated by the following case

The patient, a male age 12, (K134 Table III) was first seen following a direct injury to the Left patella No fracture was present but it was noted, as an incidental finding in the radiograph that he had an anomaly of ossification in the lateral femoral condyle He was kept under observation in the knowledge that the lesion at this particular site would probably heal spontaneously This assumption proved to be true but five months later a lesion was noted in the medial condyle Radiographs taken at this time showed abnormalities of ossification of similar type in the capitellum in both elbow joints. The lesion in the medial femoral condyle was kept under observation in the hope that it would follow a similar course to that on the lateral side. Seven months later that is to say one year from the time of the original attendance, not only had it failed to heal but the patient had related symptoms in the form of pain and giving way incidents of almost weekly occurrence It was considered at this stage that the symptoms were due to lack of support of the articular cartilage and the presence of a flat area in the contour of the medial femoral condyle indicated absorption of underlying bone It was decided therefore that operative interference was indicated to prevent further deformity or even separation of the area involved It was noted that the lesions in the elbow joints had healed radiologically and it was presumed that this occurred for the same reason that the lesion in the lateral femoral condyle had healed they were not exposed to the stress to which the medial femoral condyle is subjected

JUVENILE OSTEOCHONDRITIS DISSECANS RELATIONSHIP TO OTHER CONDITIONS

The frequency with which irregularity of ossification in the lower femoral epiphysis is encountered and the radiological similarity between findings classified as Type II and III and the lesion of osteochondritis dissecans can lead to erroneous conclusions by those who seek evidence of the etiology of this condition Unless normal variants are recognised as such an association could be claimed between almost any morbid condition occurring before puberty and osteochondritis dissecans if radiographs of the knee joints have been taken in the course of the investigation

RELATIONSHIP TO JUVENILE OSTEOCHONDROSIS (JUVENILE OSTEOCHONDRITIS) AND ENCHONDRAL DYSOSTOSIS

The etiology and relationship to one another of the large number of epiphyseal affections the major example of which is Perthes disease, has long been a matter of controversy If trauma is implicated in the etiology of *osteochondritis dissecans, it is considered also to be implicated* in the etiology of the various juvenile osteochondroses. Like osteochondritis dissecans too additional if even less well defined constitutional factors have been recognised. Goff (1954) who has developed the theme credits Sinding Larsen (1915) with the original recognition of the constitutional character of Perthes disease and with the application of the term syndrome ' to the malady

Goff in classifying the conditions involving aseptic necrosis of the ossific centres recognised three types of epiphysis

1 **Pressure** components of joints which frequently bear weight and are always subject to pressure from muscular contraction

2. **Traction** serve as bony attachments of tendons and

3 **Atavistic** so called because phylogenetically they are remnants of structures no longer serving their original functions in man.

The osteochondroses with familiar names affecting pressure epiphyses are listed. The unnamed varieties are legion. There is no epiphysis at which an osteochondritis has not been described

Perthes disease of upper femoral epiphysis

Köhler s disease of tarsal navicular

Scheuermann s disease of vertebral epiphyseal plates

Calvé s disease of vertebral body

Freiberg s disease of metatarsal head

Theimann s disease of proximal centre of phalanx and

Panner s disease of capitellum

The named varieties affecting the traction epiphyses are listed Any attachment of tendon to epiphysis can be affected

Osgood Schlatter s disease of tibial tubercle

Sever s disease of calcaneum and

Sinding Larsen Johansson s disease of upper or lower pole of patella.

Goff seeks to draw a clear distinction between the conditions affecting the pressure epiphyses which he calls " true osteochondroses " and which form part of a syndrome and those affecting the tension and atavistic epiphyses, which he calls " false osteochondroses " and which he considers to be of traumatic origin and not part of a syndrome

Few observers would disagree with the concept underlying the distinction It conforms to the author s views on Schlatter s and Sinding Larsen Johansson s disease previously expressed (Smillie 1951) It is doubtful if even in traction epiphysitis a dysostotic element or hereditary factor can be entirely eliminated So fine a distinction cannot be drawn (see page 29 and Figs 2, 11 and 2, 12)





FIG 2, 11 FIG. 2, 12

Osteochondritis Dissecans: Familial Variety

Knee joints of the elder of two brothers (A. S., aged 14 K162, and R. S., aged 12, K157 Table III) He had a lesion in the medial femoral condyle of the Right knee (Fig. 2, 11) His younger brother had lesions of both medial femoral condyles. The elder s Left knee showed no osteochondritis dissecans lesion, but multipolar ossification of the patella and traction epiphysitis at the lower pole (Fig. 2, 12)

Almost every variety of osteochondritis, named and unnamed of pressure traction and atavistic epiphysis was encountered in the course of investigation of the cases. In some the findings were incidental but in others, the association especially with conditions affecting the pressure epiphyses was too close not to suggest a common etiological factor

Enchondral dysostosis constitutes the most frequent hereditary disease of the skeletal system in man (Mau 1958) If this concept is accepted an etiological factor exists for a vast catalogue of affections of bone which ranges from the extremes of osteochondrodytrophy Morquio s or Brailsford s disease or Hereditary Multiple Epiphyseal Disturbance (Ribbing) through the juvenile osteochondroses of the pressure epiphyses named and unnamed to

the most local but from the practical viewpoint, most important form of all osteochondritis dissecans

A dysostotic growth disturbance was in evidence in general and in local forms and in wide variation of degree throughout the juvenile cases in the series The factor of a hereditary constitutional disposition may be so slight as to become apparent only as a result of mechanical influence The role of trauma, particularly repeated microtrauma in the production, localisation and nature of the lesion is the subject of constant reference throughout the text.

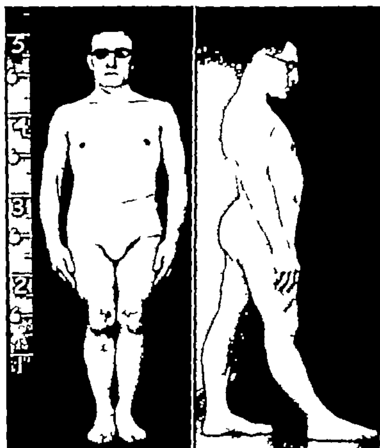


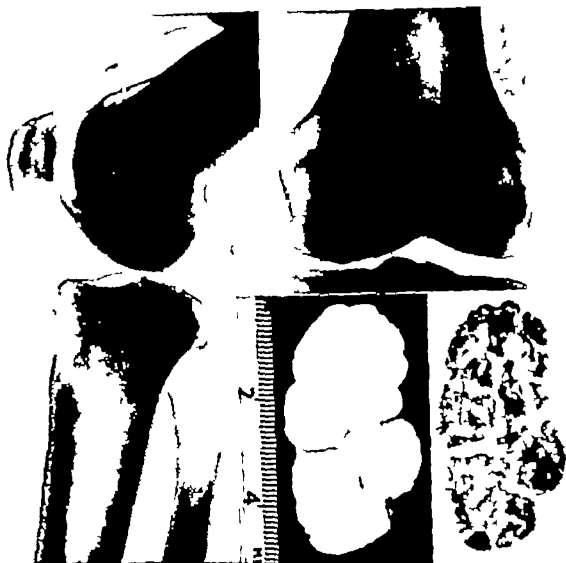
FIG. 2, 13 FIG. 2, 14

Dysostotic Factor in Osteochondritis Dissecans

Stature and physique of patient with bilateral symmetrical lesions at classical site from which loose bodies had separated (Fig. 2, 13). Lateral view to show genu recurvatum (Fig. 2, 14) (D W male aged 19 K107 Table *III*)

Dysostotic cartilage ossification in the epiphyses according to Mau is characterised by (1) late appearance of centres of ossification (2) delayed skeletal maturation particularly of the dissociated variety *i e* delayed maturation in the presence of normal maturation (3) relatively small size of

epiphyseal centres (4) epiphyses wider and flatter than normal and with all skeletal proportions changed in this direction the patient is of short stature (5) tendency to formation of accessory centres of ossification and multipolar ossification



FIGS. 2, 15 18

Dysostotic Factor in Osteochondritis Dissecans

Lateral radiograph of Right knee to show premature closure of upper tibial epiphysis and multiple loose bodies (Fig. 2, 15 *top left*) Antero-posterior radiograph of Left knee to show old lesion at classical site and large loose body in suprapatellar pouch (Fig. 2, 16, *top right*) Loose body from Left knee to show irregular hypertrophy of cartilage (Fig. 2, 17 *bottom left*), and the radiograph (Fig. 2, 18, *bottom right*). (D W., male aged 19 K107 Table III)

An example of the dysostotic constitution in easily recognisable form with disturbances of metaphyseal longitudinal growth as well as disturbance of growth of the epiphyseal centres is quoted in the case of D W male aged 19 (K107 Table III) The patient was of short, broad stature almost

giving the impression of achondroplasia His height was 5′ 1″ and his legs short by comparison with his trunk. Both knees showed marked hyperextension and it was clear from his radiographs that premature closure of the anterior aspect of the tibial epiphyses had occurred. The osteochondritis dissecans lesions, instead of being located at the classical site, were situated in the middle of the medial femoral condyles of both knees A considerable proportion of the articular surfaces appeared to be involved The reason for admission to hospital was the presence of several large loose bodies in the Right knee (Figs. 2, 13 to 18)

Not all bilateral examples have such conspicuous epiphyseal or metaphyseal growth disturbances. *In many unilateral cases the constitutional* factor may be even less easy to recognise The less common varieties affecting multiple joints (page 31) and variety affecting families (page 29) are the most outstanding examples of the constitutional aspect of enchondral dysostosis as it affects osteochondritis dissecans

RELATIONSHIP TO ABNORMALITIES OF ENDOCRINE FUNCTION

Growing bone is vulnerable to metabolic changes produced by endocrine dysfunction. Growth maturity and mineral balance are all subject to alteration by changes or abnormality of endocrine secretion

It is not proposed that this subject be approached in other than the most general terms it is a matter of extreme complexity That hormone imbalance is responsible for abnormalities of epiphyseal growth is well established Perhaps best known to orthopaedic surgeons is the relationship of Fröhlich s syndrome (Dystrophia Adiposo-Genitalis) to Slipped Upper Femoral Epiphysis (*Epiphyseolysis Adolescent Coxa Vara*) That it is related also to osteochondritis dissecans was demonstrated on many occasions in this series.

If the theory that normal rapidity of growth at the lower end of the femur is responsible for anomalies of ossification at that site it is exceptional rapidity of growth which may be responsible for the transition from anomaly of ossification to the pathological process under consideration Cases K119 and K143 (Table III) are outstanding recent examples of such transition where height and weight for age were so exceptional that they were considered worthy of record There were numerous other instances where such details were not entered. In this respect it should be stated that one indirect hormonal influence could be nothing more than excessive pressure on a pressure epiphysis from excessive body weight

At the opposite end of the scale Roberts and Hughes (1950) recorded the case of a girl aged 11 a dwarf with lesions in both elbows, both patellae

and both medial femoral condyles White (1957) in associating the condition with dwarfism recorded three further cases a woman aged 28 4 ft. 4 ins tall with poorly developed secondary sexual characteristics who had loose bodies in both Right knee and Right hip The lesion in the knee was located in the medial femoral condyle a man aged 21 4 ft 6 ins tall with poorly developed secondary sex characteristics who had a lesion in the capitellum in the Right elbow at the age of 16 and within a year lesions in both knee joints. The lesions were apparently located in the lateral condyles and a woman aged 21 4 ft 5 ins tall said to have the appearance of a child of 8 years who had lesions in both elbow joints located in the capitellum and a year later lesions in the Right knee and the Right ankle joints

All three cases were stated to show radiological evidence of osteochondritis juvenalis in the thoracic spine

Experience of this series indicates that the relationship of osteochondritis dissecans to endocrine dysfunction temporary or permanent, takes three forms

1 Increased tendency to anomalies of ossification and thus to the development of superimposed pathological changes. Examples have been quoted.

2. Inherent weakness of subchondral bone. The relationship of the vulnerability of subchondral bone to the normal nutrition of articular cartilage will be developed in a later section. The zone appears to be particularly liable to fracture from trivial causes in the presence of endocrine dysfunction as the following case illustrates

The patient, (J C., male, aged 19 K142, Table III) was admitted following an incident while playing cricket when his knee locked. He gave a history that six months previously while playfully wrestling with a friend he had experienced a sharp pain in the knee during a rotating movement, followed by swelling about one hour later Radiological examination revealed the presence of a loose body in the suprapatellar pouch that part depicted consisting of a thin sliver of cortical bone At operation the cartilage component of the fragment had the contour of a condyle and the site was located to the lateral condyle on the antero-inferior surface. It was an osteochondral fracture produced by contact with the patella the patella was intact. It was noticed in the course of taking the *history* that the patient looked and acted much more like a boy of 12 than of his 19 years *Inquiry* revealed that he was under treatment for an endocrine dysfunction of the Fröhlich type.

This relationship probably provides the explanation of the relatively small group of cases where a massive fragment, usually from the medial femoral condyle has been displaced in some quite trivial injury mechanism

It is as if a large area had been twisted from the articular surface by the screw home movement of the knee joint.

3 Inherent tendency to deformity of joints. The development of deformities of joints in general bone disease of endocrine origin in which premature and disorderly closure of epiphyses occur renders such joints liable to osteochondritis dissecans In considering lesions in the knee joints in subjects such as dwarfs where the endocrine relationship seems obvious, a distinction must be drawn between cases arising from the effect on local areas in the epiphysis and those arising from deformity of the joint as a whole.

It may be found, for example, that the common deformity of genu recurvatum is present. The lesion may thus be adult osteochondritis dissecans of mechanical origin and secondary to the deformity and abnormal mechanics of the joint concerned (see page 55)

Complexity of relationship. It is not intended however it may appear to convey the impression that the complex relationship between endocrine dysfunction and osteochondritis dissecans can be classified under three simple headings That two or more factors, none of which can be isolated, may operate in one patient, and without the intervention of the precursor stage of an anomaly of ossification is demonstrated in the case

G M., male aged 15 (K144 Table III), recorded to have been of Fröhlich type, was first seen at the age of 12 with recurrent subluxation of the Left patella. Radiographs at that time showed no evidence of an anomaly of ossification. An operation for the relief of the subluxation consisting of transplantation of the patellar tendon to the medial side of the tibial head, was performed elsewhere. This procedure carried out at the age of 12, was, not surprisingly followed by premature closure of the anterior part of the upper tibial epiphysis and consequent back knee and valgus deformity of considerable degree. When last seen at the age of 15 the complaint was of the appearance of the knee rather than of any disturbance of function but a radiograph taken at that time showed a well marked lesion in the lateral femoral condyle

This case demonstrates (1) that osteochondritis dissecans can arise at the age of 14 without the intervention of an anomaly of ossification (2) that a disturbance of endocrine function may render the epiphysis vulnerable to injury (3) that alteration of mechanics particularly if it involves genu recurvatum, may be responsible for an osteochondritis dissecans lesion (4) that alteration of mechanics, in this instance genu valgum may be responsible for the location of the lesion In this patient the location of the lesion in the lateral femoral condyle was caused by the valgus deformity producing an increase of pressure on the lateral side Examination of the radiographs

showed unmistakable evidence that the lateral eminence of the tibial spine was contacting the lateral femoral condyle

VARIETY AFFECTING FAMILIES

One family only was encountered in which more than one member was affected The record is important as evidence of the etiology of the Juvenile variety

The father a doctor presented the first of the patients (R S aged 12, K157 Table III) when his Right knee became swollen A radiograph demonstrated a lesion in the centre of the medial femoral condyle. The Left knee showed the same condition at a more advanced stage Both were considered to have progressed from anomalies of ossification to the established lesion. Both were subjected to the drilling operation The doctor father then presented the eldest son (A S aged 14 K162, Table III) with a massive lesion in the medial femoral condyle of the Right knee No osteochondritis dissecans lesion was seen in the Left knee but he was noted to have an anomaly of the patella consisting of multipolar ossification with one large fragment and at least two smaller ones at the usual site at the supralateral margin In addition he had a well marked Sinding Larsen Johansson traction epiphysitis at the lower pole (Figs. 2, 11 and 2, 12) On the Right side that in which the medial femoral condyle was affected, he showed an Osgood Schlatter traction epiphysitis of the upper tibial epiphysis

This family demonstrates (1) the dysostotic factor in the etiology of the Juvenile variety (2) the hereditary nature of the factor (3) anomalies of ossification in medial condyle as the precursor of osteochondritis dissecans (4) that the dysostotic factor may be present in traction epiphysitis (5) the relationship between osteochondritis dissecans and the other juvenile osteochondroses.

That osteochondritis dissecans can exist in several members of a family is firmly established by numerous references in the literature

Bernstein (1925) recorded a bilateral affection of the knee in two sisters and a brother

Wagoner and Cohn (1931) recorded instances in two families. In one, father son and paternal uncle had one knee affected in the other both knee joints of two brothers were involved.

Rahm (1934) reported the occurrence of the condition in the elbow joints of two brothers where symptoms appeared at the age of 16 Four male relatives, two uncles and two cousins were similarly affected all in the Right elbow and all with symptoms appearing at the age of 14 to 16

Novotny (1952) has recorded the condition in the medial femoral condyle of the knee *in two brothers in the elder at age 12, in the fully developed* state in the younger at age 11½ at the anomaly of ossification stage.

Gardiner (1955) noted a family in which two brothers and a sister were affected. In the brothers both knees were involved

Pick (1955) instanced a family in which a mother and three of four daughters showed the condition In one aged 13 the capitellum of both elbow joints was involved. A second aged 14 showed the condition in the medial femoral condyle in both knees The third, aged 10 had no symptoms but is recorded to have shown typical changes of osteochondritis dissecans in both medial femoral condyles. Examination of the reproductions of the radiographs of this particular member however shows what appear to be anomalies of ossification rather than established osteochondritis dissecans. It is thus to be assumed that the condition in the joints of the other members arose through the medium of anomalies of ossification The youngest daughter was aged 5 at the time of the radiographic examination which is said to have revealed no abnormality It is of interest also that the mother of the family was only four feet six inches in height, and all the children about six inches below the normal height for age. In other respects they were of normal development.

Tobin (1957) has recorded osteochondritis dissecans in the knee joints in a father two sons and a daughter the male members suffering from tibia vara He thought that the osteochondritis dissecans probably pre-dated, from the chronological viewpoint, the development of the tibial bowing In studying the reproductions of the radiographs it is of interest to note that in the eldest son a radiograph at 10 years old shows an anomaly of ossification (Type II) in the lateral femoral condyle A later radiograph at the age of 15 shows a normal lateral femoral condyle but the development of an osteochondritis dissecans lesion towards the centre of the medial condyle From this observation and the appearances of the remaining radiographs, it is considered that they are examples of Juvenile osteochondritis dissecans arising through the medium of anomalies of ossification and that Tobin's conclusion regarding the order of development is correct.

It is not possible to form any definite conclusion regarding the disease as it occurs in families It is not accepted that the examples quoted are evidence that osteochondritis dissecans in general is hereditary It is not the primary condition in most of the cases recorded but incidental to some undetermined hereditary disturbance of epiphyseal growth

The several possibilities to be considered when osteochondritis dissecans occurs in two or more members of one family are (1) that a tendency exists

for anomalies of ossification in joints and thus the tendency to develop osteochondritis dissecans in the knee joint This may be the explanation of Novotny s cases (2) that there is a dysostotic constitutional background This may be the explanation of the family quoted by Pick where the members affected were of abnormally short stature (3) that the families concerned suffer from a form of hereditary multiple epiphyseal disturbance (4) that joints of a particular conformation are liable to osteochondritis dissecans (page 38) and that certain members of a family may have joints of similar anatomical form This would provide a reasonable explanation in the family whose elbow joints were affected as reported by Rahm

VARIETY AFFECTING MULTIPLE JOINTS

Osteochondritis dissecans affecting both knees or both elbows is a common finding (Tables III and V) It is thus not surprising to find references to bilateral loose bodies in the earliest literature (Weichselbaum 1873 Clutton 1887 Koenig 1888 Clarke 1890 Lane 1893 Championniere 1894 Morton 1896 Le Conte 1896 Hammesfahr 1897 Carothers 1914 Henderson 1923 and others) The lesions may be symmetrical (Figs 2, 19 to 2, 22) but are not necessarily so The medial condyle may be affected on one side and the lateral on the other (K115 Table III) or the patella on one side and the patella and medial condyle on the other (K146 Table III) Two or more different joints may be involved, for example a knee and hip on the same side (K81 Table III and H3 Table VII) or both hips and both elbows (Watson Jones 1940) Reference has been made to various combinations of joint lesions in dwarfs (Roberts and Hughes 1950 White 1957) on page 26

The impression was gained that bilateral symmetrical lesions arose either from anomalies of ossification or for mechanical reasons whereas bilateral asymmetrical lesions (case K81 Table III) and examples involving two or more unrelated joints arose in disorders of endocrine function

In addition to these relatively common combinations there exists a variety which appears to be rare, in which a large number of joints including joints not otherwise affected individually are involved There was no evidence in the examples to be recorded that such cases are familial nor was there obvious evidence of disorder of endocrine function

Example 1 This case (Dr K Zobell, Germany personal communication) is recorded as of particular interest because it was the only example encountered of osteochondritis dissecans in the active stage affecting the metacarpo-phalangeal



FIG. 2, 19



FIG. 2, 20



FIG. 2, 21



FIG. 2, 22

Bilateral Symmetrical Lesions of the Juvenile Variety

The loose body has separated on the Left side (Figs. 2, 19 and 2, 21). The fragment has not yet separated on the Right side (Figs. 2, 20 and 2, 22). One of the points which may help to distinguish Juvenile osteochondritis dissecans from the Adult variety is the presence of multiple areas of ossification within the crater of the lesion in the radiograph. Two or three or more round or oval-shaped areas may be seen which bear no definite relationship to one another (Fig. 2, 2.). They indicate that the pathological lesion has arisen in an anomaly of ossification. In Adult osteochondritis dissecans two or sometimes even three fragments make up the bone element, but the fragments are related to one another and are the result of fractures superimposed on the original bone element.

joints and showing radiographic features comparable with Freiberg's infraction of the metatarsal head

The patient, a male aged 18 years of tall, slim build came under observation following a minor injury to the fifth metacarpo-phalangeal joint of the Right hand. In the radiograph taken at that time was seen a lesion of undetermined pathology in the head of the fifth metacarpal When the pain failed to subside and discomfort was complained of in the third metacarpo-phalangeal joint, further radiographs showed a lesion in the head of the third similar to that originally seen in the fifth (Fig. 2, 23) In the course of investigation, the Left hand was found to show a similar lesion in the third metacarpal head although there was no history of injury to that hand nor complaint of pain or discomfort (Fig. 2, 24)

In the course of taking the patient's history it transpired that for some considerable time he had experienced aching in both knees together with stiffness which occurred when he remained in one position for any length of time Radiographs of the knees showed typical osteochondritis dissecans lesions located about the middle of the medial femoral condyle on both sides. In a similar position in the lateral femoral condyle on both sides was an irregularity which gave the impression of a healed lesion. The appearances of all four lesions were consistent with juvenile osteochondritis dissecans arising in an anomaly of ossification (Figs 2, 25 and 2, 26)

The question of endocrine dysfunction did not arise All investigations, biochemical and otherwise, proved to be negative.

The authenticity of the lesions in this patient's metacarpo-phalangeal joints might have been open to question if the classical appearance of Juvenile osteochondritis dissecans in both knee joints had not been discovered in the course of investigation. The point of particular interest was that the radiological appearance of the lesions in the metacarpal heads gave the impression of having arisen like the lesions in the knee joints, in an anomaly of ossification

Example 2. The patient (referred by Mr George Hay Orthopaedic Department, Stracathro Hospital Angus Scotland) a male aged 31 years (case H5 Table VII) gave a history of trouble with both elbow joints and both hip joints at the age of 14 His complaint at that time was of inability to attain full extension in the elbow joints. He had experienced locking incidents in both joints ever since At the time he first complained of his elbows he complained also of stiffness in both hips His troubles now involved a knee joint, both hips, both elbows, hands and feet.

Radiographic examination of the joints revealed the following positive findings

Elbow joints Both joints contained loose bodies in the anterior compartment. The anatomy was abnormal in so far as the head of the radius was enlarged and displaced anteriorly Advanced osteoarthritis was present and as a result it was



Fig. 2, 23



Fig. 2, 24

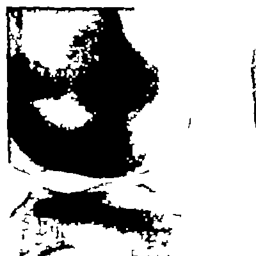


Fig. 2, 25



Fig. 2, 26



Fig. 2, 27



Fig. 2, 28

Variety affecting Multiple Joints

Lesions were present in the second and fifth metacarpal heads on the Right side (Fig. 2, 23) and in the third metacarpal head on the Left side (Fig. 2, 24). Medial femoral condyle on Right side (Fig. 2, 25). A similar lesion was present in Left knee (Fig. 2, 26). Lesions, probably anomalies of ossification, in the lateral condyles had healed (Fig. 2, 26). Symmetrical irregularity of conformation of ankle joints but no osteochondritis dissecans lesions (Figs. 2, 27 and 2, 28). Dr K. Zobell's case.

impossible to say whether the loose bodies had arisen from the capitellum or from the head of the radius

Metacarpo-phalangeal joints Right—there was enlargement and distortion of the heads of the second and third metacarpals. The changes were of similar variety to that recorded in Example 1 but gave the impression of a more advanced stage The appearance could reasonably be called healed osteochondritis dissecans

Hip joints Both joints show changes typical of osteochondritis dissecans

Knee joints The Right joint showed a lesion at the classical site in the medial femoral condyle The appearances were those of the Juvenile variety

Ankle and tarsus On both sides the superior surface of the talus was irregular and on both sides the navicular bifid and the talo-navicular joint distorted

Metatarso-phalangeal joints The second and third metatarsal heads on both sides show the appearance of healed Freiberg s infraction The distortion of the heads was similar in appearance to that seen in the second and third metacarpal heads.

There is a striking similarity between these two cases, the second in an older patient being a more advanced stage. In both the lesions appear to have arisen in a disturbance of epiphyseal growth occurring at or about the time when Juvenile osteochondritis dissecans normally arises It is of particular interest that the second example showed typical lesions affecting not only the metacarpal heads but the metatarsal heads and that, as in Freiberg s infraction it was the second and third metacarpal heads which were affected The case possibly provides further evidence linking Freiberg s infraction with osteochondritis dissecans of the Juvenile variety affecting the knee joint.

In the second example no explanation is offered why the Left knee of all joints should have escaped entirely

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CHAPTER 3

ADULT OSTEOCHONDRITIS DISSECANS

DEFINITION If trauma is accepted as it must be, to play some part in the production of all types of osteochondritis dissecans lesion it can be aid to play the major part in the Adult variety

Constitutional factors exerting direct influence on growing bone are not n evidence and affect the situation only in so far as they may have determined he final form of the joint.

EVIDENCE IMPLICATING TRAUMA

If ischaemia is the basic pathology in Juvenile osteochondritis dissecans t is implicated also in the Adult variety but not in the same way In Juvenile osteochondritis dissecans trauma is superimposed on ischaemic bone to produce the lesion In the adult, internal trauma produces the ischaemia and continuing produces the lesion

Constantly repeated minor traumata have a diletenous effect on the blood supply of bone. The example frequently quoted and cited here as evidence is that of Kienböck s disease of the carpal navicular as a result of the use of pneumatic tools Constant impingement between tibial spine and femoral condyle head of radius and capitellum, talus and tibia has the same effect and upon the ischaemic bone is then superimposed the fatigue fracture to produce the lesion which finally results in the discharge of a loose body into the joint

In the production of the lesion it is necessary to distinguish between the stress fracture which occurs in living bone capable of reacting, but which has failed to react in time to the stress placed upon it (March fracture) and a fatigue fracture occurring in ischaemic or dead bone unable like an inert metal to react That dead bone does in fact sustain fatigue fractures in a similar manner to metal has been demonstrated experimentally (Walmsley and Smith 1956)

OSTEOCHONDRITIS DISSECANS OCCURS ONLY ON SURFACES TO WHICH A TANGENTIAL FORCE CAN BE APPLIED

The sites in the joints at which a lesion widely accepted as osteochondritis dissecans is most frequently encountered are

Knee joint

1 Classical site infra-lateral aspect medial femoral condyle
2 Infra-central aspect medial femoral condyle
3 Infra-central aspect lateral femoral condyle
4 Antero-lateral aspect lateral femoral condyle

Metatarso-phalangeal joints

Supra-distal aspect metatarsal head

Elbow joint

1 Antero-inferior aspect capitellum.
2. Margin of head of radius

Ankle joint

1 Supra medial aspect talus.
2 Supra lateral aspect talus.

Hip joint

Superior aspect head of femur

These sites, widely varying in conformation have one feature in c[
location on convex surfaces, that is to say in situations to which ta[
forces internal or external can be applied.

It is not proposed at this stage to expand the argument or exp[
means by which the causative forces are applied at the particular sit[
will be dealt with in the chapters devoted to the individual joints. [
appear that a single exception to the rule is present in the hip [
condition is so rare in this joint that the occurrence can reasonabl[
garded as an exception capable of explanation but incapable of inva[
the principle involved

INTERNAL TRAUMA: ENDOGENOUS MECHANICAL FACT[

In the engineering industry in the course of assembly of con[
parts is what is known as tolerances This, in non technical terms,[
described as the limit of size in say thousandths of an inch on the [
minus side of normal which is acceptable if the machine in producti[
run smoothly It is said that the chance misfortune of the fitting tog[
a working part at the limit of tolerance on the plus side with one at t[
of tolerance on the minus side results in a unit which lacks the smooth [
characteristics which exemplify the normal If the premise is accept[
Adult osteochondritis dissecans is neither a disease nor an anomaly of[
but due to abnormal contact between the component parts of a joi[

something akin to the tolerances of engineering must operate in human joints otherwise the condition under consideration would be widespread

That tolerances are an important factor in the vulnerability of joints is widely accepted if not recognised as such In the hip joint to take the best example too shallow an acetabulum predisposes to the development of a wear and tear arthritis but too deep an acetabulum predisposes to exactly the same thing There is a certain depth which is normal and there are limits on either side of normal but the joint must be neither too shallow nor too deep

The same limit of tolerance may operate in the ankle joint. The bone at the junction of the horizontal with the vertical planes may be vulnerable if the angle is too sharp that is the radius too small or vulnerable for a very different reason namely instability if the angle is too blunt, that is the radius too great.

The delicate balance in the relationship between the components of certain joints can be altered in the course of growth (genu recurvatum page 55) or in the course of wear and tear or ageing (page 58) Thus the liability of a joint of particular anatomical type to develop the lesion may be decided by the occupation pursued or in the recreational field to cite an example be influenced by the decision to indulge in games of football or in games of chess.

THE NATURE OF THE NUTRITION OF ARTICULAR CARTILAGE RENDERS SUBCHONDRAL BONE VULNERABLE TO INJURY

Adult bone retains certain structural differences which prevail between epiphysis and metaphysis during growth (Lacroix 1956) This is exemplified in acute post traumatic osteoporosis where the radiographic translucency appears first at the metaphysis (Fig. 3, 1) What is of interest from the view point of the etiology of osteochondritis dissecans is the presence of radio-translucency at the periphery of the femoral condyle and of more import ance the band of dense bone between the unseen articular cartilage and the translucent zone This dense line demonstrates conclusively that there is a layer of bone immediately deep to articular cartilage in which the blood supply is less than that of the deeper cancellous tissue This finding, of course is not unexpected in view of the fact that articular cartilage has no blood supply It is simply that at the junction of bone with articular cartilage blood supply must taper off to zero This is the layer of bone however which lacking a blood supply is vulnerable to injury (Fig. 3, 2)

Lesions on broad convex surfaces which do not include a margin tend to contain but a small bony element Separation of articular cartilage as a

result of repeated injury takes place through the vulnerable surface layers of the bone Examples of such circumstances are the centre of either femoral condyle or best of all the capitellum



FIG. 3, 1

Subchondral Bone is Vulnerable to Injury

Post traumatic decalcification in adult knee joint. Note band of radio-translucency indicating hyperaemia, at metaphysis, and narrow dense band of radio-opacity indicating ischaemia, deep to the articular cartilage of the femoral condyle. There is a wide band of radio-translucency deep to the dense band.

FIG. 3, 2

Articular Cartilage has No Blood Supply



Two loose bodies to show effect of abnormal blood supply Upper was completely free. Note normal quality of articular cartilage. Lower had attained a synovial attachment. Note thinning and absorption of articular cartilage

Even in the single incident osteochondral fractures of the margin of the lateral femoral condyle produced either by contact applied from the lateral side by an external force or from the inner side in subluxation of the patella, it is to be noted that the fracture takes place through the layers of bone immediately deep to the dense area to which the cartilage is attached. It is a thin layer of bone not a triangular shaped fragment such as might be expected from the nature of the violence In articular fracture there is no tendency for separation to occur between bone and cartilage (Landells 1957)

When the site includes a sharp edge or margin which can be subjected to a more definite blow (rather than the tangential blow received by a broad

convex surface) the lesion tends to contain a larger bony element Examples of such circumstances are the classical site on the lateral margin of the medial femoral condyle the talus, on either medial or lateral aspect and the head of the radius.

SINGLE INCIDENT FRACTURES

Amongst the many contradictions and difficulties which arise in writing about osteochondritis dissecans is the differentiation from osteochondral fracture It is a matter of differentiating between a fracture produced by a single injury and one produced by repeated small mechanical actions within a joint. If trauma is to be cited as an important factor in the etiology the single accident must be eliminated Therein lies the first of the difficulties The fragment may not separate immediately and in any event, the end result, in terms of the formation of a loose body and the lesion on the articular surface from which it arose, may not be materially different from that encountered in true osteochondritis dissecans

There are three fractures in the knee to which these remarks apply but single-injury fractures which can be mistaken for osteochondritis dissecans occur also in the head of radius or capitellum and indeed can occur anywhere In the knee, the tangential osteochondral fracture of the patella associated with recurrent dislocation the counterpart on the lateral femoral condyle produced by the same mechanism and the osteochondral fracture of the lateral femoral condyle produced by external violence are examples of fractures liable to be missed in the recent state and the resulting lesions liable to misinterpretation at a later date

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CHAPTER 4

KNEE JOINT

THE knee is the largest and most important joint affected by conditions of traumatic origin It is evidence supporting the traumatic theory in the etiology of osteochondritis dissecans that it is the joint most commonly affected

On a former occasion when an opinion was expressed (Smillie 1951) the constitutional factor operating in addition to trauma at the classical site was considered to be the hereditary anatomical form of the joint. This view may still be true and, as will be seen apply to both Juvenile and Adult varieties but time has shown as the preceding Chapters indicate that it is only part of the story The prevalent error of that era in surgery was the voicing of opinions based frequently on an adequate volume of clinical material but encountered in conditions of war and thus limited often by sex and always by age group

It is proposed at this stage to muster the evidence implicating internal trauma the endogenous mechanical factor in osteochondritis dissecans of the knee, whether at the classical or other site, subject only to considerations developed in the preceding Chapters It is proposed also to show that the form of the joint, congenital or acquired influences the onset of the condition at the classical site in the Adult variety The responsibility of form in determining the onset of the Juvenile variety was not defined in relation to the other factors involved and has not been developed except in so far as certain general statements apply to the knee joint at all ages

THE LATERAL ASPECT OF THE MEDIAL FEMORAL CONDYLE IS VULNERABLE TO INJURY

In an investigation (Smillie 1954) undertaken to determine the mechanism of rupture of the anterior cruciate ligament, observations were made at the termination of operation in 1000 consecutive meniscectomies in order to establish and record the state of the ligament. These 1000 cases revealed the total of 215 lesions in the form of total rupture or gross attenuation Of these, 169 were associated with 659 lesions of the medial 38 with 321 lesions of the lateral and 8 with 10 lesions of both menisci It seemed reasonable to assume a relationship between lesions of the medial meniscus in particular and rupture of the anterior cruciate ligament

If the function of the ligament is to guide lateral rotation of the tibia in the last few degrees of extension that is to say control the screw home movement on which the stability of the joint depends any attempt to extend the joint without concomitant lateral rotation of the tibia puts it on the stretch rupture occurs if the forces involved are sufficiently great This is the explanation of the means whereby a longitudinal tear of the medial meniscus and a rupture of the anterior cruciate ligament can be co-existing lesions produced by the same rotary mechanism in a football accident. But experience of the series suggested that the major proportion of cruciate lesions

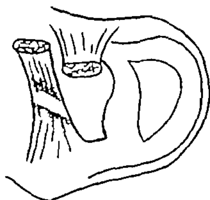


Fig. 4, 1

The Lateral Aspect of the Medial Femoral Condyle is Vulnerable to Injury

Fig 4, 1 Diagrammatic representation of lesion on anterior cruciate ligament due to contact with lateral aspect of medial femoral condyle encountered in displaced longitudinal (bucket-handle) tear of medial meniscus producing locking of the joint. Fig 4 2. Opposing lesion on lateral margin medial femoral condyle from contact with ligament.



Fig. 4 2

occur not as acute injuries but only after a complete longitudinal or bucket handle tear of the meniscus has become displaced into the centre of the joint. The outstanding clinical feature of such circumstances is locking of the knee a phenomenon which presents as the inability to achieve full extension What is more important as far as the anterior cruciate ligament is concerned is the positive block to lateral rotation of the tibia which the meniscus displacement entails Any attempt to secure full extension in the presence of obstruction to the screw-home movement occurs only at the expense of the ligament

The mechanics of the situation can be demonstrated at operation on the permanently displaced complete longitudinal tear In such circumstances not

only does forced extension exert traction on the ligament, but in the proc
of forced extension the ligament actually impinges against the articul
margin of the lateral aspect of the medial femoral condyle In a recent ca
a pale area, corresponding to the site of contact with the condyle and bound
above and below by an area of injection may be seen on the ligament (F
4, 1) If the case is of longer duration there may be evidence of impingeme
not only on the ligament but on the margin of the condyle in the form
irregularity or erosion of the articular cartilage (Fig. 4, 2)

The oblique pale area where in cases of some duration the ligament
devoid of synovial covering, is close to the attachment, and the inferior ed
at or about the level of the tibial spine. Observations have shown that t
area of pressure is most evident in the recent case after a period of enforc
bed-rest immediately prior to operation the patient lies on his back wi
the leg extended but the joint, of course is not screwed home.

The extent of the evidence of pressure in the form of erosion of t
cartilaginous margin of the condyle varies It is not confined to one spot b
extends over that segment of the condyle where friction occurs within t
range used in the action of walking (Fig 4, 2) It is thus most marked at t
point where it touches with the joint extended but not screwed home, a
then tapers off in intensity from before backwards as pressure lessens
reaching, say 150 Visual evidence of pressure on this segment of the co
dyle is readily available. It is present in almost every case of permanent
displaced longitudinal tear on the medial side of the joint. Radiologic
evidence is less commonly seen. Fig. 4, 3 shows an area of decalcification
the medial femoral condyle from pressure of the ligament, and possibly al
from the torn meniscus in a case wrongly placed in a plaster cast in forc
extension following the false reduction of a longitudinal tear

The most convincing evidence of all exists in the form of an acute lesi
which appears like a clean-cut incision beginning in the intercondylar notch
and extending round the lateral margin of the condyle on to the centre of the
articular surface. It has taken place in a direction from before backwards so
that it is most shallow anteriorly and deepest posteriorly The cut corres-
ponds accurately to what would normally be the anterior edge of an
osteochondritis dissecans lesion at the classical site (Fig. 4, 4)

What is the explanation of this lesion? It is so clean-cut that it gives
the impression that it was produced by a sharp knife and yet, when the
margins are opposed there is no gap such as might be caused by the edge of
a blade Occurring from before backwards and from within outwards it can
only be a split produced at the instant of locking as a result of the extreme
pressure exerted on the margin of the condyle when the centrally displaced

portion of the torn meniscus is jammed into the space between condyle and attachment of cruciate ligament

Once this lesion had been observed it was seen with increasing frequency Originally it was thought to accompany only longitudinal meniscus tears producing locking incidents but it was noted and the cause thus confirmed in the presence of a small loose body jammed between the condyles In one





FIG 4, 3 FIG. 4 4

Etiology of Osteochondritis Dissecans: Cases Illustrating Vulnerability of Lateral Margin Medial Femoral Condyle

FIG. 4, 3 Lateral radiograph showing area of decalcification on medial condyle of femur as a result of pressure from displaced longitudinal (bucket handle) tear of medial meniscus. Area involved is classical site for osteochondritis dissecans. (W N., male, aged 53).
FIG. 4, 4 Lesion on lateral margin of medial femoral condyle encountered in complete longitudinal tears of medial meniscus in which there has been a recent violent locking incident. Split begins in intercondylar notch and extends round margin on to centre of articular surface Note clean cut margins which close completely on pressure. Note tibial attachment of anterior cruciate ligament with oblique pale area to which reference is made in text (page 44).

such case two parallel lesions were seen which apparently represented two separate locking incidents. The lesion may be found also in the centre of a condyle just as an osteochondritis dissecans lesion may be found at this site and for a similar reason namely the presence of a tag of meniscus producing compression of a moving weight-bearing surface

The vertical columns of cells which comprise articular cartilage indicate the weight-bearing nature of the function it performs This arrangement however does not appear to be able to withstand the application of a tangential force which tends to produce a fracture at right angles to the surface, that is to say parallel to the columns of cells

SPINE OF TIBIA EVIDENCE OF CONTACT

The theory that contact between medial tubercle of tibial spine and femoral condyle is responsible for the lesion is widely held but remains the subject of debate.

If the spine of the tibia is capable of inflicting injury on the medial condyle of the femur between the extremes of abrasion and osteo-articular fracture then it is reasonable to expect to find manifestations of impact in the medial tubercle and the evidence is most likely to be present where the *condyle has inflicted damage on the spine rather than the reverse.*

The radiological evidence of injury varies in degree

1 *Sclerosis* The inference to be drawn from increase of density in the medial tubercle is that of contact of a minor nature over a long period of time (Fig. 4, 5)

2 *Flattening* Unmistakable evidence of this degree is most frequently encountered where instability is known to exist or wear and tear arthritis has brought femur and tibia into closer contact (Figs 4, 6 and 4, 7)

3 *Fracture* A fracture of the tip of the medial tubercle can only occur by impact It should be distinguished from the traction lesion which is a rupture of the anterior cruciate ligament in the form of a fracture of the entire tibial spine. *Occasionally osteochondritis dissecans and evidence of impact in the form of* fracture are present in the same knee (Fig 4 8)

FORM OF THE SPINE (INTERCONDYLAR EMINENCE)

Examination of any unselected series of knee joint radiographs demonstrates that there are few areas in the human skeleton which show such *widely varying conformations as* the head of the tibia In some the table is flat with the spine hardly perceptible (Fig. 4, 7) in some the medial tubercle of the spine is large and prominent (Fig 4, 8) while in others the spine is high in relation to condyles which instead of the common upward inclination towards the periphery slope downwards

In upholding the traumatic theory on a p ... casion (Smillie 1946 reference was made to the apparent promin ... medial tubercle the *tibial spine* in the cases under review ... 33) supporting contact theory recorded the observation th ... writers had ca attention to what they regarded as the excess ... medial tub in lesions located at the classical site The dur ... of the co versy is illustrated by ... vation (Freiberg ... essive heig the medial eminenc ... is unnecessary ... occur



Fig. 4, 5



Fig. 4, 6

Radiological Evidence in Medial Tubercle of Tibial Spine of Contact with Femoral Condyle

Fig. 4, 5 Relationship of medial tubercle to lesion on femoral condyle and density of tubercle
Fig. 4, 6 Flattening of medial tubercle from contact with condyle of femur



Fig. 4, 7



Fig. 4, 8

Radiological Evidence in Medial Tubercle of Tibial Spine of Contact with Femoral Condyle

Fig. 4, 7 Distortion of both tubercles from contact with condyles (*female aged 50 with wear and tear changes from untreated medial meniscus lesion producing constantly recurring incidents*) Fig. 4, 8 Fracture of tip of medial tubercle associated with lesion at the classical site



FIG. 4, 9



FIG. 4, 10

The conformation of the head of the tibia and in particular the spine (intercondylar eminence), varies within wide limits. The possibility of impingement with medial condyle of femur seems remote in Figure 4, 9 (hypoplasia of spine), but might occur in Figure 4, 10 (hyperplasia of medial tubercle)

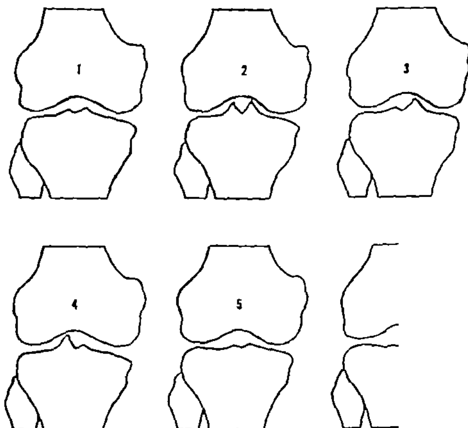


FIG. 4, 11

Diagrammatic Representation of Variations of the Intercondylar of the Knee Joint (after Giorgi)

(1) Normal) Hyperplasia. (3) Hyperplasia of medial tubercle (p 5 of lateral tubercle (5) Hypoplasia. (6) Aplasia.

RELATIONSHIP OF FORM OF SPINE TO LESION AT CLASSICAL SITE

In order to determine if a relationship exists between the form of the tibial spine, such as presented in the average projections available and the presence of a lesion at the classical site antero-posterior radiographs of one hundred consecutive lesions were compared with the radiographs of a similar number of consecutive unselected cases reporting with some other condition of the knee

To apply some yardstick to the various forms encountered it was necessary to find a classification emanating from a source unprejudiced by preconceived ideas Giorgi (1956) investigating the numerous variations of the tibial spine came to the conclusion that anomalies characterised by either hyperplasia or hypoplasia do not cause alterations in the mechanics of the knee joint. The investigation was not directed towards the etiology of osteochondritis dissecans This classification was therefore adopted (Fig. 4, 11)

The hundred examples at the classical site consisted of eighty-six from Table III radiographs of which were immediately available and the remainder made up with unselected cases not included in the present series. One knee only from bilateral cases was considered.

TABLE I

Classification of Variations of Tibial Spine	*Knees reporting with other Conditions*	*Knees with Osteochondritis Dissecans at Classical Site*
Normal	50	16
Hyperplasia	15	34
Hyperplasia of medial tubercle	26	48
Hyperplasia of lateral tubercle	0	0
Hypoplasia	9	2
Aplasia	0	0
	100	100

Table I would appear to indicate a definite relationship between a prominent spine or prominent medial tubercle of spine and the classical site lesion.

It is not intended however to convey the impression that the results of the investigation are unchallengeable It was soon evident that whether a knee was classified as normal or hyperplasia could depend on the angle at which the radiograph was taken and based entirely on what radiographs were available the outcome could not be taken too seriously Nevertheless there remains the definite impression that the spine of the tibia is a prominent

feature in the radiograph where the lesion is located at the classical site. There remains also the feeling that Freiberg's contention that excessive height is unnecessary for contact to occur had been confirmed.

In classifying the cases with the lesion at the classical site and in so doing seeing the radiographs where the lesion was located elsewhere, it became clear that if the impression was given that the medial tubercle of the tibial spine is prominent or both medial and lateral tubercles prominent, it was not so much the prominence of the spine that mattered as the shape of the tibial table as a whole. It was evident also in cases located at all sites, that a deformity of the tibial head easily recognised as such was frequently present. The deformities most in evidence were broadening and flattening, which tended to throw the spine into prominence and flattening in the lateral view the result of retardation of growth or premature closure of the anterior aspect of the epiphysis

It is not unlikely that similar variations occur in the conformation of the femoral condyles although such variations may be more difficult both to detect and to define Most important of all may be certain combinations of variation in tibial head and femoral condyles which bring medial tubercle and medial condyle into abnormally close proximity

It is recorded again that pressure on the anterior aspect of the upper tibial epiphysis, by decreasing blood supply produces retardation of growth. In the same way alteration in the blood supply of the lower femoral and/or upper tibial epiphysis from disease or injury or the treatment of disease or injury by bed-rest, traction or plaster fixation may alter the shape of the opposing condyles. Interference with the blood supply at the periphery of the lower femoral epiphysis produces broadening of the condyles interference at the centre narrowing. It is not unlikely that it is such influences, in minor degree which are responsible for the alterations in contour which make contact possible

ADDITIONAL FACTORS WHICH INCREASE THE RISK OF CONTACT BETWEEN SPINE AND CONDYLE

If it is accepted that the lesion at the classical site is the result of contact between the medial eminence of the spine of a tibia of particular conformation and the medial femoral condyle possibly also of particular conformation then it will be shown that certain other factors, anatomical and pathological increase the likelihood of contact. Alternatively that these factors may bring about contact in joints of such conformation that it would not otherwise occur



FIG. 4, 12

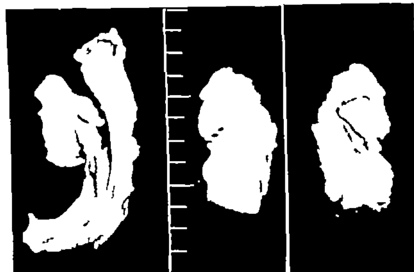


FIG. 4, 13 FIG. 4, 14 FIG. 4 15

Massive defect on the lateral aspect of the medial femoral condyle (Fig. 4, 12) and the associated torn meniscus (Fig. 4, 13) The anterior cruciate ligament was ruptured. The articular cartilage of the loose body was fractured (Fig 4 14), the site of fracture determined by the position of the dense bone element on the deep surface (Fig. 4, 15). (Scale in inches.) The defect could have been repaired

1 **Instability** It is clear that internal derangements producing instability will increase the risk of contact. The causes of instability most frequently associated with osteochondritis dissecans at the classical site in this series were



Fig. 4, 16



Fig. 4, 17 Fig. 4, 18 Fig. 4, 19

The lesion is in the centre of the medial condyle and coincided with the compressed anterior extremity of a displaced longitudinal (bucket-handle) tear of the meniscus with the knee in extension (Fig. 4, 16) The loose body (Fig. 4, 17), the deep surface of which consisted of minute fragments of bone over which cartilage cells were proliferating (Fig. 4, 18) and the radiograph (Fig. 4, 19). Separation had taken place through the surface layer of the cancellous tissue. (Scale in inches.) The defect could have been repaired.

(a) *Lesions of menisci* Under this heading is included the curious phenomenon of a lesion of a congenital discoid lateral meniscus

apparently associated with a lesion of the classical site There is no direct relationship it is the result of instability (Figs 4, 12 to 4, 21)

(*b*) *Rupture of anterior cruciate ligament* There is a relationship between ruptures of the anterior cruciate ligament and tears of the medial meniscus (page 42) Thus (a) and (b) may be combined (Figs 4, 12 to 4, 21)

(*c*) *Recurrent subluxation of the patella*



Fig 4 20 Fig. 4, 21

Instability increases risk of impingement

Fig. 4, 20 Lesion on medial femoral condyle from impingement of medial tubercle of tibial spine in rupture of anterior cruciate ligament and *horizontal cleavage lesion of posterior* segment of medial meniscus. Lesion involves cartilage only base of crater is vascular bone *It is not true osteochondritis dissecans* (A. T., male aged 27 professional Rugby League football player not included in list) Fig. 4, 21 Cartilaginous lesion at classical site showing unmistakable evidence of repeated impingement by tibial spine Rupture of posterior cruciate ligament and tear posterior segment of medial meniscus were present. (Not true osteochrondritis dissecans although included in list (W K., male, aged 27 K72, *Table III*) by reason of radiological lesion in underlying bone).

2. **Back-knee (genu recurvatum).** The association of this deformity with the lesion of the classical site is of common occurrence. It is significant that the knee affected is usually that with the greater deformity The relationship can be explained on the basis of the disturbance of joint mechanics but particularly of the screw home movement, which this deformity entails (Figs 4, 22 to 4, 25)

3 **Decrease of joint space.** Any condition which decreases the interval between femur and tibia must increase the risk of contact. These are

(*a*) *Removal of a meniscus* particularly from the medial side of the joint



Fig. 4, 22

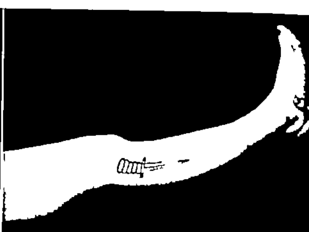


Fig. 4, 23

Figs. 4, 22 4, 25

Etiology of Adult Osteochondritis Dissecans: Alteration of Mechanics of Joint: Back-Knee (Genu Recurvatum)

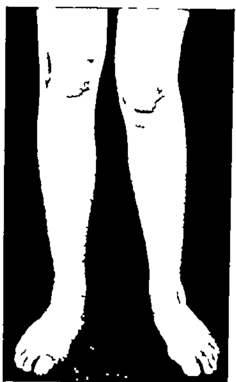


Fig. 4, 24



Fig. 4 25

Fig. 4, [illegible] Type of adult joint liable to develop lesion at classical site. Fig. 4 23 Knee of case (W G., male aged 29 K1?9 Table III), with lesion in medial femoral condyle. The patient, a Corporal in the Black Watch, had a skean dhu tattooed on his leg. It directs attention to the deformity of the tibia which is the cause of his lesion. Figs. 4, 24 and 4, 25 Back knee with algus deformity the result of transplantation of the tibial tubercle for recurrent subluxat n of patella before cessation of growth. The lesion was located in the lateral condyle (G M male aged 15 K144 Table III)

Sk dhu a short dagger carried in the stocking of Highland dress.
N r kean dhu nor leg is normally curved !

(b) *Reduction of the internal substance of the meniscus* as in the hori zontal cleavage lesion

(c) *Osteoarthritis* Flattening of the medial eminence of the spine is a common finding in the radiographs of this condition and can be the result only of direct contact (Figs 4, 26 and 4, 27)

IN THE ADULT VARIETY, LOCATED AT THE CLASSICAL OR OTHER SITE, THE CAUSE OF THE LOCAL TRAUMA IS USUALLY EVIDENT

When osteochondritis dissecans of the knee joint arises in the young dult, say 18 to 25 or at middle age the cause of the lesion can usually be etermined. If it is located at the classical site there will exist some new ircumstance not acting at age 10 to 15 which allows the tibial spine to ome in contact with the femoral condyle

In the young adult the common causes are

1 **Back-knee deformity (genu recurvatum)** It is presumed that the ffect of this deformity on the mechanics of the knee joint is insidious and occurs during the years of maximum athletic activity which follow the pre-nature closure of the anterior aspect of the upper tibial epiphysis.

In the acquired, as opposed to the variety which is a manifestation of he dysostotic constitution, it is pressure on the epiphysis which causes retardation of growth or premature closure This is the explanation of the genu recurvatum deformity which can follow a long period of enforced bed rest for any cause in the supine position in childhood with the knees in extension and unsupported. The anterior part of the upper tibial epiphysis is under pressure with consequent diminution of blood supply and retardation of growth.

It is of particular significance that this is the usual cause found in young women It is well known that patello-femoral arthritis is much more common in the female subject than in the male and is the direct result of the wearing of high heels. It is obvious that if the heel is raised difficulty is encountered in extending the knee the joint tends to be used in slight flexion and thus the patella is pressed hard back against the femoral condyles in the erect position In time the articular cartilage wears and patello-femoral arthritis develops. It is probable that back knee deformity is of similar origin. If an adolescent girl wears high heels before growth is completed she must tend to press the knees backwards otherwise she would require to walk with the knees flexed This force constantly applied increases the pressure on the anterior aspect of the upper tibial epiphysis which therefore tends to close



FIG. 4 26

Adult Osteochondritis Dissecans

Knee joint of female who developed lesion at aged 51 (D D K109 Table III) Note square contour of medial femoral condyle and high medial tubercle of tibial spine blunted by contact with condyle



FIG 4, 27

Adult Osteochondritis Dissecans

Knee joint of male who developed lesion at aged 76 (J W K89 *Table III*) Note *degenerative changes* and *relationship of* medial tubercle of tibial spine to separating *fragment*.

earlier than the posterior part The deformity which results is related in degree to the interval in time between the raising of the heels and the closure of the epiphysis.

Two cases are recalled to illustrate some of the points raised under this heading

1 J S., a female aged 22 (case K117 Table III) who exhibited a well marked lesion at the classical site but whose radiographs, taken six years previously showed no lesion This patient was by occupation a teacher of dancing, and the out standing feature of her clinical examination was the hyperextension of her knees. The radiograph showed a high tibial spine adjacent to the lesion and at operation the fact that the tibial attachment of the anterior cruciate ligament was coming in contact with the lateral aspect of the femoral condyle was not in doubt.

The degree of hyperextension present at the knees was greater than is normally expected from the wearing of high heels at an early age. There was no evidence of the so-called dysostotic constitution nor of abnormal hyperextension at the elbow joints. In going into her history in detail in an attempt to discover the explanation it transpired that before the age at which she could remember she had been confined to bed for eighteen months she thought, with what her mother had been informed was pulmonary tuberculosis.

In proof of the contention that a lesion at the classical site is produced by impingement of the tibial spine and in proof of the contention that pre mature closure of the anterior part of the upper tibial epiphysis and the genu recurvatum which results increases the tendency to impingement is quoted the case of

2. A coal miner who was first seen at the age of 17 with an injury of the knee The diagnosis of a torn medial meniscus was made and at operation a horizontal cleavage lesion of the posterior segment was found. It is the custom in the Unit to record from observation at operation the state of the anterior cruciate ligament. In this patient s notes the record reads "Inspection of the interior of the knee joint revealed some roughening of the lateral edge of the medial femoral condyle and the anterior cruciate ligament although intact was reddened and noted to butt against the condyle."

The extraordinary thing about this case is that six years later the patient reported having sustained a locking incident of the type associated with the presence of a loose body When a radiograph was taken not only was a large loose body seen but the source defined at the classical site on the medial femoral condyle. Here then is an example of a case in which the conditions liable to result in osteochon dritis dissecans are known to have existed prior to the production of the lesion To add to the interest in relation to the theories propounded, is the fact that the lateral radiograph shows premature closure of the upper tibial epiphysis and a back knee.

2. **Rupture of anterior cruciate ligament.** In a joint of configuration which makes contact between spine and condyle possible the increased antero-posterior mobility which follows rupture of a cruciate ligament may be sufficient to produce the lesion The liability is increased further if rupture of the ligament is associated with a lesion of the posterior segment of the medial meniscus of the horizontal cleavage type which brings femur and tibia into closer relationship

In illustration of this point is quoted the case of

A. T., age 27 a professional Rugby League footballer At operation for an internal derangement of long standing relative to the medial meniscus the posterior half was the subject of a horizontal cleavage lesion in which the whole structure with the exception of the extreme periphery had been worn away The medial femoral condyle had as a result settled down on to the tibial head and the bare tibial spine was coming in contact with the medial femoral condyle and had produced a lesion of quite considerable dimensions. It was not of the typical osteochondritis dissecans type however in that pieces of articular cartilage had been shed off from time to time leaving the bone quite bare. The base of the crater consisted of vascular bone without the usual barrier of sclerosis. The tibial spine was also denuded of soft tissue where it came in contact with the condyle but whether the anterior cruciate ligament had been ruptured in a football incident or whether it had been ruptured by contact with the condyle was impossible to determine (Fig. 4, 20).

In middle age the new circumstances are conditions which result in reduction of joint space

1 **Degenerative lesions of the posterior segment of the medial meniscus,** particularly the horizontal cleavage lesion which eventually results in the grinding away of the substance of the fibrocartilage.

2. **Excision of one or other or both menisci.**

3 **Wear and tear arthritis (osteoarthritis)** and the thinning of the articular cartilage which this condition implies (Figs. 4, 26 and 4, 27)

In illustration of (2) and (3) above is quoted the case of

J L a male age 35 (case K101 Table III) who gave a history that in 1945 both menisci were removed by a General Surgeon. He was first seen by an Orthopaedic Surgeon in 1954 and a radiograph taken at that time showed osteoarthritis of the wear and tear variety No radiological lesion was detectable in the medial femoral cond l In 1956 a loose body had separated and a radiograph determined the site of ion to be the medial femoral condyle. At operation for the removal of body not only was the site of the lesion confirmed but the attachment rior cruciate ligament to the tibial spine was seen to be worn

and the bone of the spine devoid of soft tissue where it came in contact with the femoral condyle.

LESIONS LOCATED IN THE CENTRE OF EITHER FEMORAL CONDYLE ARE USUALLY DUE TO AN UNDERLYING TORN MENISCUS

It is difficult to explain the origin of a typical lesion in the centre of the inferior aspect of either femoral condyle on other than a traumatic basis when directly opposing the site is a torn meniscus (Figs. 4, 16 to 4, 19) This finding has been recorded and illustrated on a former occasion (Smillie 1946) and has not escaped the attention of other observers (Bonnin 1946) The tear takes one of several forms (a) on either side a complete longitudinal tear with the central portion displaced towards the centre of the joint (Fig 4, 12 to 4, 15) (b) on either side a tear of longitudinal or horizontal cleavage type with a hypertrophied tag based anteriorly protruding towards the centre of the joint and (c) on the lateral side a torn congenital disc (cases K87 and K113 Table III)

On exposing a lesion associated with a complete longitudinal tear it will be seen that the defect in the condyle lies between the peripheral and central portions and corresponds to the anterior extremity of the tear in maximum extension The fibrocartilage is seen to be thin and attenuated at the anterior extremity of the tear as a result of repeated impact between condyle of the femur and head of the tibia

Where the meniscus injury takes the form of a pedunculated tag based anteriorly the position of the defect in the femoral condyle is more variable The hypertrophied tag traumatises the condyle either by being trapped between it and the tibial head or between it and the peripheral portion of the meniscus Thus the defect may occur at any point in the breadth of the articular surface

The loose body from the curved centre of the articular surface consists principally of cartilage with only small flakes of bone from the line of cleavage in the vulnerable ischaemic surface of the cancellous tissue (Fig 4, 18) If the site has included a margin of the condyle a larger fragment of bone may be included (Fig. 4, 15)

The origin of the bone pathology is not in doubt constantly repeated impingement produced by the simple act of walking produces local vascular changes in the underlying bone at the site of impact. The trauma continuing, the ischaemic possibly dead bone becomes the site of a fatigue fracture and the closed horizontal cleavage lesion previously described (page 19) becomes the eventual source of an osteochondral loose body

It has been stated that the factors responsible for the adult lesion act at all ages (page 11) Case K113 Table III is an example of the Adult variety the result of a torn congenital disc in a child aged 12 (See also page 130)

NATURE OF LOCAL LESION IN RELATION TO ETIOLOGY

The basic pathology whatever it may be, affects bone not cartilage, which remains intact in the face of a gross underlying lesion. Even when every vestige of support is gone an isthmus persists which retains the appear ance of normal until the final incident when it gives way and the loose body is cast into the joint. It will be noted throughout this work that in the description of the local lesion, particularly in the knee and metatarso-phalangeal joints constant reference will be made to this isthmus or hinge which is the final attachment of the osteo-articular fragment to the parent body

This attachment can reasonably be expected to be located on the opposite side from the direction of the force which produced the fracture. At the classical site the final isthmus is usually located on the medial aspect and confirms that the causative force was applied from the lateral side. It was known early in the series that a lesion could exist at the classical site which communicated with the intercondylar notch in the absence of any indication of abnormality in the overlying cartilage. This feature alone, without further evidence, would indicate the direction from which the force was applied (Figs 4, 28 and 4, 29)

In order to demonstrate the phenomenon it was necessary to wait for cases in which there was a gross radiological lesion but no abnormality of cartilage It is of course, seldom possible to see the line of fracture in th intercondylar notch and not always possible to enter the point of a button-hook retractor into it. Such were the circumstances of the first experiment

1 M M., male age 14 (case K119 Table III) In this case, when a straight probe had been driven through the articular cartilage into the horizontal cleavage a needle closed distally but with a lateral opening near the distal end, was thrust into the probe hole until it reached the line of cleavage. Saline was then injected with a syringe It flowed freely into the intercondylar notch. The experiment was repeated on three occasions with the same result.

Further proof was obtained in the course of treatment when a probe was driven through normal articular cartilage into the cleavage and on into the vascular bone beyond On withdrawal not only did blood exude but a bubble of air ap-peared. This air could come only from the intercondylar notch (Fig. 4, 29).

2. In another case (P K., female, aged 11 case K130, Table III), although there was n[illegible] whatever on the surface, not only was it possible to demonstrate

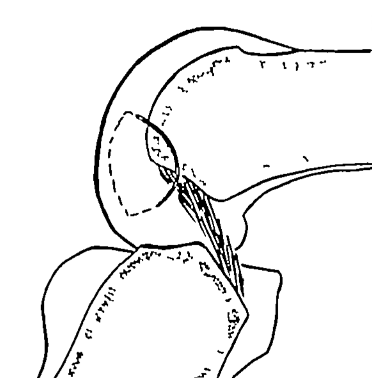


Fig. 4, 28



Fig 4, 29

Pathological Anatomy of Lesion at Classical Site

Fig. 4, 28 Diagrammatic representation of lesion at classical site with fracture entering intercondylar notch showing relationship of posterior cruciate ligament. Fig 4, 29 Lesion involving more than half diameter of medial condyle. At operation the overlying articular cartilage was normal but the fracture line communicated with the intercondylar notch (see text) (M M., male, aged 14 K119 Table III)

that a large area of articular cartilage was loose by inserting a button-hook retractor into the line of cleavage and exerting traction, but when a stab wound was made an angled probe could be passed into the lesion and rotated It was shown also that once the zone of cleavage had filled with blood as a result of the drilling procedures pulling on the tibial head exerted a pumping action so that blood exuded and then receded through the stab wound. This pump-like action is of significance because it demonstrated what happens at each movement of the joint, and the action must be greatly exaggerated in weight-bearing.

The presence of a fracture which enters the intercondylar notch at the point at which the force was applied raises the possibility that the lesion might occur in the first place as a result of a single incident of internal trauma

In the osteoarticular fracture of normal bone the force required to fracture cancellous tissue is sufficient to fracture the overlying cartilage at least on the aspect from which the force was applied An attachment of cartilage may remain but only on the opposite side Circumstances in which a recent fracture at the classical site is encountered are exceptional. One case reported previously (Smillie 1946) illustrates the point

The patient, a young adult male gave a history that his knee had been subjected to a twisting injury in a fall down some steps. A diagnosis of a torn medial meniscus was made and the joint opened after an interval of a week. The diagnosis was found to be wrong, but a fresh fracture, in the usual area affected by osteochondritis dissecans, was noted There was unmistakable evidence of trauma to the medial side of the tibial spine, and it was clear that impingement of the spine against the femur was responsible for the fracture. The fragment of articular cartilage and bone was not displaced and the fracture was only detected by the presence of a hairline crack in the articular cartilage When the straight chisel-type knife was inserted into the crack the fragment was found to have no attachment other than a small hinge of intact cartilage and a few strands of the posterior cruciate ligament. A further haematoma was noted on the lateral side of the fragment where it had been struck by the tibial spine. Re-examination of the original radiographs after the operation and with the knowledge of the exact site of the fracture did not reveal any sign of the lesion

It is not possible to reproduce in postmortem material the circumstances of the various forces involved in a mechanical incident in a knee joint in the process of weight-bearing. The evidence available suggests that a fracture of normal healthy bone is probably impossible without at least an incomplete fracture of the overlying articular cartilage

The curious feature of the osteochondritis dissecans lesion and surely the aspect of the pathological anatomy which has given rise to more controversy than any other is the fact that a fracture or horizontal cleavage lesion as it has been called here can be completely closed, that is to say have no

opening towards the side from which the trauma occurred No evidence was forthcoming from any source that a fracture within a joint from endogenous or exogenous forces of the single-incident variety can take this form It is a feature of repeated injury in ischaemic degenerate bone just as the horizontal cleavage lesion in the fibrocartilage of a meniscus is a feature of ischaemic degenerate tissue unable to react to the repeated forces applied to it (see also page 18)

In the course of the application of conservative surgery what appeared to be a significant observation concerning the etiology of the condition was made during the preparation of the bony element of the loose body prior to return to the crater and also at the driving of the nails used as a means of internal fixation

If the bony element of the fragment is of any considerable dimensions it will be found to be exceptionally dense and resistant to penetration by sharp-pointed instruments But even more impressive is the characteristic of brittleness. In the course of attempting to break up the superficial layers in the hope that a blood supply will be attained the bone will suddenly fracture Similarly a nail which can be driven without difficulty through normal bone frequently cannot be made to penetrate persistence leads to bending of the nail or sudden fracture of the fragment

The bone at the base of the crater is comparably dense and sclerotic It is necessary to penetrate some distance into the condyle before normal vascular cancellous tissue is reached These findings tend to confirm the contention that the *fracture is a fatigue fracture occurring in bone previously grossly* abnormal as a result of ischaemia relative or absolute If the fracture was a simple osteochondral fracture from a single incident of violence which for some reason had progressed to non-union no such depth of sclerosis would be encountered The brittleness of the bony element of the loose body may be an indication of the manner in which the fatigue fracture occurred.

RELATIONSHIP OF POSTERIOR CRUCIATE LIGAMENT TO LESION AT CLASSICAL SITE

If the anterior cruciate ligament is concerned in determining the vulnerability of the lateral aspect of the medial femoral condyle the posterior cruciate ligament is concerned in the pathological anatomy of the lesion at the classical site

It is a common experience in removing a partially free loose body or in the application of conservative surgery to the classical site, that the osteo-cartilaginous fragment retains an attachment of posterior cruciate ligament There are occasions in the repair of the site when this attachment is helpful

in providing a fixed point during preparation of the bony element, and, eventually the correct position for return to the crater What part the ligament plays in determining the nature of the lesion or what part it plays in the natural history of the disease was not discovered It is assumed that the attachment to part of a ligament entails the presence of some blood supply but it seems unlikely that this has any influence on healing. On the other hand it was thought probable that attachment to part of a ligament concerned in stabilisation might prevent healing as a result of the distraction to which the fragment must be subjected in every movement of the joint. This possibility influenced the decision to divide the attachment in certain cases subjected to conservative surgery but in which rigid immobilisation was considered to be unnecessary in the after treatment, lest even non weight-bearing exercise prevent healing (Figs 4, 28 and 4, 30)



FIG 4 30
Large lesion at classical site on medial femoral condyle There is a recent fracture of the fragment the upper half of which is displaced into the inter condylar notch attached by a portion of posterior cruciate ligament.

OSTEOCHONDRITIS DISSECANS OF LATERAL CONDYLE OF TIBIA

Two patients were encountered with lesions of the lateral tibial condyle, one unilateral the other bilateral In the first, there was a lesion of the lateral femoral condyle in the opposite knee (K155 Table III) and in the medial femoral condyle of one side in the bilateral example (K159 Table III) The fact that both these cases were noted towards the end of the series casts doubt on the apparent rarity of the condition Rescrutiny of knee radiographs might reveal further examples The first case was discovered in peculiar circumstances and is recorded

The boy (T J aged 12, K155 Table III) was first seen with giving way incident in the left knee, then of two years duration A radiograph showed what was c[illegible]d to be an anomaly of ossification in the lateral femoral condyle. At the s[illegible] irregularities were noted on the antero-superior aspect of the femoral cond[illegible] the patella which tended to confirm the probability of an anomaly

of ossification The final clinical decision made was that the symptoms were referable to his patella His symptoms ceased within one year but in a follow up examination one year later he complained of pain and giving way symptoms this time in the right knee. It was not appreciated on this occasion that the knee of



FIG. 4 31



FIG. 4, 32
Bilateral osteochondritis of knee involving the lateral femoral condyle on Left side (Fig. 4, 32) and the lateral tibial condyle on Right (Fig.4 31) (T J., male, aged 14 K155 Table III)

which he complained was the right one not the original left. When seen three years from the first examination, radiographs of both knees showed not only a lesion in the lateral femoral condyle on the left side almost certainly the transition from anomaly of ossification to osteochondritis dissecans, but what had not been encountered before a lesion in the lateral condyle of the tibia on the right side (Figs 4, 31 and 4, 32) He complained of pain in the right knee, the site of the tibial lesion, but had no symptoms referable to the lesion in the lateral femoral condyle on the left side.

It is of interest to note that osteochondritis of the entire superior tibial epiphysis has been recorded previously (Boldero and Mitchell 1954) but not, as far as is known the local variety

OSTEOCHONDRITIS DISSECANS OF PATELLA

If lateral marginal fractures the result of a single direct injury and medial tangential osteochondral fractures from single or repeated lateral dislocations, are excluded, some doubt might be cast on the existence of true osteochondritis dissecans of the patella The majority of apparent examples which were encountered fell into the latter category and no such case has been recorded in Table III It is admitted in the circumstances of the production of the tangential osteochondral fracture that conditions could exist in which a lesion could be produced indistinguishable in etiology and pathology from true osteochondritis dissecans (see page 69) There exists however another lesion of the patella apparently uncommon which has all the characteristics of the osteochondritis dissecans lesion The mechanical aspect of the production is obscure Five such cases are recorded in Table III One case (A. D male aged 20 K146 Table III) is quoted the authenticity of which is unlikely to be challenged

The patient, an undoubted example of the dysostotic constitution, presented with locking of the Right knee the result of a loose body in the suprapatellar pouch (Fig 4, 38) On investigation the lesion was located in the patella and found to be bilateral and symmetrical Both were observed at operation, and as if to make confirmation of the nature of the pathology complete a massive lesion of the medial femoral condyle in the Left knee was diagnosed radiologically and eventually repaired surgically (Figs 9 27 9 28 9 29 and 9, 30) The patella lesion was located midway between superior and inferior poles on the medial aspect and extended in area to the mid line of the bone On the Right side the osteo-cartilaginous fragment was free as a loose body in the joint. On the Left, it lay in the crater anchored, as in typical osteochondritis fashion, by a remaining tag of articular cartilage. Where the fragment was free the constant motion of the bone over the femoral condyles had separated tags of articular cartilage from the periphery of the crater and these projected into the joint to be responsible for recurring mechanical incidents (Fig. 4, 34)

It is recorded above that this variety of osteochondritis dissecans is at least uncommon It is possible that more cases exist than are detected and that a large rounded osteochondral loose body of mysterious origin could originate from such a source. In the radiology of the knee it is generally assumed that a tangential view of the patella is the projection which shows up

a defect whether it be a lateral marginal fracture or tangential osteochondral fracture on the medial side but this does not necessarily apply to osteochondritis dissecans if the lesion is located half way between the superior and inferior poles Bone is superimposed on the defect and it may not be seen in any view other than the ordinary lateral projection It is of interest that a radiograph similar in appearance to Fig. 4, 33 has been used by De Palma (1954) to illustrate this particular form of osteochondritis dissecans





FIG 4, 34

Bilateral Osteochondritis Dissecans of Patella

FIG 4, 33 Right Lesion located middle of medial margin seen in lateral projection only with loose body in suprapatellar pouch. FIG 4, 34 Left Articular surface patella which has been rotated seen from the lateral side. Lesion on medial aspect from which fragment has not yet separated (A D male aged 20 K146 Table III)

FIG 4, 33

CERTAIN TANGENTIAL OSTEOCHONDRAL FRACTURES RELATIONSHIP TO OSTEOCHONDRITIS DISSECANS

Reference has been made already in general terms (Chapter 3) to three common osteochondral fractures in the knee which may be confused with osteochondritis dissecans. Each may produce a loose body of bone and articular cartilage and leave a crater similar to osteochondritis dissecans If the fragment is displaced into the joint as a free loose body on the occasion of a single incident of trauma the condition is not osteochondritis dissecans But such injuries are more often missed than diagnosed even when the

opportunity is offered and even following radiographic examination bone element is relatively small and the shadow cast is minimal. Th present as loose bodies producing locking incidents weeks, months or ye later and the longer the interval the less the likelihood of the correct conc sion regarding mode of origin



FIG. 4, 35
Tangential osteochondral fracture of lateral condyle of femur (exogenous) Note vessels in base of crater and staining of synovial membrane from haemarthrosis. Contrast with typical osteochondritis dissecans lesion

Whether the residual lesion in the articular surface is the result of fract or osteochondritis dissecans may be of no practical importance But it is academic interest because it has some bearing on the etiology of osteoch dritis dissecans. In a recent fracture the joint is the subject of a haem throsis or bloodstained effusion, the result of haemorrhage from expo cancellous tissue The interstices of the bony element of the fragment filled with blood so that adhesion to synovial membrane is not uncomm The clot in the base of the crater is eventually organised to become fibr tissue to blend and become congruous with the surrounding articular cartil Therein lies the difference from true osteochondritis dissecans. In it fracture occurs in ischaemic bone There is no haemorrhage and theref there is no fibrous tissue lining the crater The base is virtually bare scler bone and the bony element of the fragment not dissimilar (Fig. 4, 35)

opportunity is offered and even following radiographic examination the bone element is relatively small and the shadow cast is minimal. They present as loose bodies producing locking incidents weeks, months or years later and the longer the interval the less the likelihood of the correct conclusion regarding mode of origin



FIG. 4, 35
Tangential osteochondral fracture of lateral condyle of femur (exogenous) Note vessels in base of crater and staining of synovial membrane from haemarthrosis. Contrast with typical osteochondritis dissecans lesion.

Whether the residual lesion in the articular surface is the result of fracture or osteochondritis dissecans may be of no practical importance. But it is of academic interest because it has some bearing on the etiology of osteochondritis dissecans. In a recent fracture the joint is the subject of a haemarthrosis, or bloodstained effusion, the result of haemorrhage from exposed cancellous tissue The interstices of the bony element of the fragment are filled with blood so that adhesion to synovial membrane is not uncommon. The clot in the base of the crater is eventually organised to become fibrous tissue to blend and become congruous with the surrounding articular cartilage. Therein lies the difference from true osteochondritis dissecans. In it the fracture occurs in ischaemic bone. There is no haemorrhage and therefore there is no fibrous tissue lining the crater The base is virtually bare sclerotic bone and the bony element of the fragment not dissimilar (Fig 4 35)

It must be admitted of course that if the fragment is not displaced immediately and retains an attachment of articular cartilage the effect of constant movement and the passage of time may so modify the appearance of the crater that a decision as to origin may be difficult unless the site of the final isthmus provides evidence that the trauma was of exogenous origin

The three common tangential osteochondral fractures in the knee are

1 **Medial tangential osteochondral fracture of the patella.** The injury is a complication of acute traumatic or recurrent subluxation or dislocation. In the course of dislocation the patella is driven laterally over the edge of the lateral condyle of the femur In passing over the edge the quadriceps, contracting in an attempt to recover the position exerts considerable tangential force which shears off a portion of the articular cartilage together with a thin layer of the underlying cancellous tissue from the postero medial aspect of the articular surface (Fig. 4, 36)

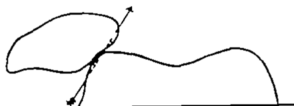


FIG. 4 36
Tangential osteochondral fracture of patella and tangential osteochondral fracture of lateral margin of lateral condyle of femur Diagrammatic representation of mechanism of production in dislocation of patella

2. **Tangential osteochondral fracture of lateral condyle of femur (endogenous)** If the margin of the lateral condyle of the femur is capable of inflicting the fracture on the articular surface of the patella described above the patella is capable of inflicting a similar fracture on the femur (Fig. 4, 36)



FIG 4, 37
Tangential osteochondral fracture of patella. The fragment is incompletely separated. Is this osteochondritis dissecans or single-incident fracture?

3 **Tangential osteochondral fracture of the lateral condyle of the femur (exogenous)** The anterior and inferior margins of the lateral condyle of the femur are exposed and vulnerable to trauma osteochondral fractures from glancing kicks or blows or from falls on the knee are much more common than is generally accepted In (2) above the causative force is exerted from within outwards In (3) it is exerted from without inwards (Fig. 4, 38)

In considering these three fractures in relation to osteochondritis dissecans, the situation which produces the greatest problem osteochondritis

dissecans or osteochondral fracture, occurs in (1) for example when subluxation occurs readily inflicting insufficient trauma to produce fracture but sufficient to produce ischaemia of bone. If eventually a fatigue fracture takes place it is difficult to see any difference in etiology or outcome from Adult osteochondritis dissecans (Fig. 4, 37)

In the tangential osteochondral fracture of the lateral condyle produced from without and in the course of weight-bearing, the support of the meniscus and tibia from below may prevent the fracture from being other than incomplete, leaving an isthmus of articular cartilage on the medial side In one such case (K122, Table III) a remnant of articular cartilage remained intact eight years after the date of probable injury (Fig. 4, 38)



FIG. 4, 38
Osteochondritis dissecans of lateral condyle, or single incident fracture? An isthmus of intact articular cartilage remained eight years after date of injury (S. E., male aged 24 K106, Table III)

SEQUELAE OF SEPARATION OF FRAGMENT

When the lesion is located at the classical site as opposed to lesions occurring elsewhere there frequently remains, even after the last isthmus of articular cartilage gives way a soft tissue attachment consisting of posterior cruciate ligament. A loose body with such an attachment may hinge in and out of the crater or rotate within the crater producing the momentary sensation of locking and even a consistent and misleading click immediately short of full extension (Figs 4, 39 to 4, 44) In some cases the loose body anchored by strands of cruciate ligament, remains within the intercondylar notch giving rise to neither symptom nor sign In most cases, with the exception of very large fragments which may become permanently wedged in

the intercondylar notch (Fig. 4, 45) the soft tissue attachment gradually attenuates and finally gives way so that the loose body becomes quite free in the joint.

Once separation occurs a loose body may

1 **Attain a synovial attachment.** It is probable that this rarely happens in true osteochondritis dissecans Re-attachment requires the medium of



FIG. 4 39



FIG. 4, 40

Two fragments of articular cartilage and bone are present, the larger of which was attached by a pedicle of posterior cruciate ligament. It hinged in and out of the crater producing recurrent locking incidents (Fig. 4, 39) The loose bodies showing the pedicle of cruciate ligament (scale in inches) (Fig. 4, 40) (This lesion could have been repaired.)

haemarthrosis. Ischaemia is the basis of the pathological anatomy haemorrhage can occur only in exceptional circumstances A loose body which has gained a synovial attachment has usually been displaced as a result of a single incident involving considerable violence It is a displaced osteoarticular fragment from a fracture of the articular surface complicated by haemarthrosis. The acute nature of the injury and the period of rest involved enables the attachment of the rough cancellous surface to the synovial membrane to become consolidated The circumstance in which a previously free loose body becomes adherent by pedicle or capsule is local haemorrhage from vascular synovial membrane injured in the course of movement of the fragment. The position in which adhesion occurs varies The most common situation is the



Fig. 4, 41



Fig. 4, 42



Fig. 4, 43



Fig. 4, 44

Fragment lying in crater in medial condyle (Fig. 4, 41) which rotated on pedicle of posterior cruciate ligament to produce locking incidents (Fig. 4, 42). Loose body outside crater still attached by ligament (Fig. 4, 43). Note influence of movement within crater on the articular margin (Fig. 4, 43) and on the final form of the loose body (Fig. 4, 44). (The defect was repaired. J. O. D., male, aged 38. K115. Table III.)

lateral compartment or the lateral aspect of the suprapatellar pouch partly because that side of the joint being exposed is more likely to be the site of fracture, and partly because the lateral aspect is the more free from displacing influences such as the medial ligament and vastus medialis The adhesion takes the form of a pedicle which frequently becomes elongated as a result of joint motion and thus permits the loose body a limited range of movement or the fragment is encapsulated by synovial membrane and the range of movement more restricted



FIG. 4, 45
Very large loose body from medial condyle lying upside down in intercondylar notch. It produced so little inconvenience that treatment was refused. (P McC., male, aged 23 K121 Table III)

2. **Remain freely mobile.** This is the probable fate of the displaced fragment or fragments in the majority of cases (Fig. 4, 46) It is the small loose body or bodies which cause the most trouble not only from locking incidents but from the resultant injury to the articular surfaces. The larger fragments are often surprisingly silent, prevented by size from escaping from the intercondylar notch or from posterior or lateral compartments A free loose body invariably increases in size as a result of proliferation of cartilage cells Initially the proliferation affects the margins but with the passage of time the whole surface may become covered with lobulated masses of cells This gradual increase in size eventually restricts movement and it becomes lodged finally in the intercondylar notch behind or in front of the cruciate ligaments, or in the lateral compartment of the joint. In the permanent situation it becomes moulded to the bone with which it is in contact If two

are present they may become moulded to one another Where movement occurs between them a joint may form (Fig. 4, 47) More than three even



FIG 4 46
Loose body from osteochondritis dissecans at classical site (N C, male, aged 42, K135 Table III) showing normal articular cartilage and dead bone.



FIG. 4 47
Loose bodies in the posterior compartment. A joint, a miniature knee joint, has formed between them.

when cast into the joint at different times are uncommon in osteochondritis dissecans

Nutritional demands of bone and cartilage The effect of attachment to synovial membrane as opposed to complete freedom within the joint and incidentally of the anticomplementary nature of the nutritional demands of bone and cartilage are demonstrated in Fig 4, 48 The three loose bodies, not from osteochondritis dissecans were in the intercondylar notch The largest was free the two smaller had a synovial attachment. The cartilage covering the largest has the quality of normal articular cartilage That covering the other two is thin and eroded. On the other hand, the quality of the bony element approaches normal in those with a blood supply but is dense and sclerotic in that without. It is assumed that each started life on an equal basis as free loose bodies Two gained a blood supply the third failed. Whether the bone of those with a blood supply grew in size is open to doubt but the cartilaginous element certainly did not. The bone of that without a blood supply did not increase in size but the cartilaginous covering certainly did and the patient in question suffered a progressive increase of flexion deformity as a result of that growth.

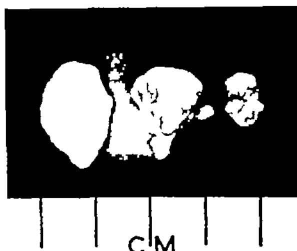


FIG. 4, 48



FIG. 4, 49

The Nutritional Demands of Cartilage and Bone are Anticomplementary

Three loose bodies (not osteochondritis dissecans) from intercondylar notch of knee joint. The largest was free The other two had an attachment to synovial membrane. Note quality of articular cartilage in loose body without blood supply and thinness and erosion of articular cartilage in those with a blood supply (Fig. 4, 48) But note also sclerosis of bone in loose body without blood supply and normal appearance of bone in those with blood supply (Fig. 4, 49)

It is of interest that the bone without the blood supply is dense and sclerotic It cannot have been so originally The increase in density must have occurred by perfusion from mineral elements of the synovial fluid





FIG. 4, 50 FIG. 4, 51

Case demonstrating Beneficial Effect of Loose Bodies in Potentially Stiff Knees

FIGS. 4, 50 and 4, 51 Supracondylar fracture of femur in process of healing showing large loose body in suprapatellar pouch.





FIG. 4, 52 FIG. 4, 53

FIGS 4, 52 and 4, 53 The fracture healed and loose body removed. Note degree of osteoarthritis in joint. (See text.)

LOOSE BODIES IN KNEE JOINT REACTION OF SYNOVIAL MEMBRANE TO SUBSEQUENT INJURY

It is the general impression that loose bodies in joints no matter what the origin are entirely objectionable and it would seem that the possibility



FIG. 4 54
Cases demonstrating Beneficial Effect of Loose Bodies in Potentially Stiff Knees
Dashboard fracture of patella with loose bodies in supra patellar pouch showing the complete return of flexion which was achieved.

FIG. 4, 54A

of an exception could not arise. But no subject in medicine is without exceptions. Even loose bodies can have a therapeutic value

The first patient in whom such an effect was noted sustained in an accident involving gross violence a supracondylar fracture of the femur with

comminution and with considerable soft tissue damage. The fracture was treated by closed reduction in the manner previously described (Smillie 1946) and satisfactory alignment obtained The nature of the injury was such that although callus appeared rapidly an unfavourable outcome in terms of knee joint movement was anticipated The prognosis as far as the function of the knee was concerned, did not seem to be improved by the presence of loose bodies in the suprapatellar pouch (Figs 4, 50 and 4, 51) and a wear and tear arthritis of considerable degree (Figs 4, 52 and 4, 53) The patient, however instead of the anticipated delay in restoring movement and probable permanent stiffness, regained a full range of flexion within two weeks of discarding his splints and before union was considered adequate for weight bearing.

The second sustained, in an automobile accident the familiar dashboard fracture of the patella well known for slow return of flexion as a result of associated contusion of the soft tissue components of the joint (Smillie 1954) He too was noted to have loose bodies in the suprapatellar pouch the effect of which was expected to be detrimental to recovery (Fig. 4, 54)

This patient repeated the experience recorded in the first case and regained a full range of movement within two weeks of release from restraint.

What is the explanation of this phenomenon? Is it that the irritation of the loose bodies produces an innocent effusion and the adhesions which would otherwise have occurred are avoided or is it that as the result of the presence of loose bodies, or of the pathology responsible for them the synovial membrane is conditioned to injury?

It would seem unlikely that such observations are without therapeutic implications for the future

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Chapter 5

METATARSO-PHALANGEAL JOINT (FREIBERG'S INFRACTION KÖHLER'S SECOND DISEASE)

Cases under review In the senes of eighty patients (Table IV) were sixty four females and sixteen males. In three all females, both feet were affected. The right foot was involved in thirty nine instances the left in thirty-eight. The second metatarsal was involved on sixty two occasions the third on fifteen The age and stage at which the cases were encountered is shown in Table II The condition thus affected females four tunes more often than males and the second metatarsal four tunes more often than the third The right and left feet appear to be equally vulnerable

Table II

Freiberg s Infraction

Stages and Ages at which Cases encountered

Stage	*Age*									
I	12	14	15	16	13	12	12	9		
II	13	13	15	14	14	12	16	12	12	12
	10									
III	15	17	15	12	11	15	18	14	13	14
	22	16								
IV	16	16	15	15	18	13	15	14	15	14
V	39	25	28	17	25	18	21	19	50	53
	18	18	22	33	13	18	22	42	48	54
	16	45	48	52	22	43	38	59	17	44
	43	40	32	33	16	41	67	52	17	41

Stages and Ages

Table II indicates the stages and ages at which the patients were encountered It establishes that Freiberg s infraction occurs in the first half of the second decade. The average age of the patients encountered in the active phases of the disease Stages I to IV was fifteen years but a tendency will be noted for higher ages in the more advanced stages. If it is possible for the earliest stages to present as late as sixteen, it is also possible for the final stage to be reached as early as thirteen

ETIOLOGY

It was evident from examination of both the feet and the relative r
graphs that the condition occurs in a structurally weak foot. One or
or all of the radiological stigmata of a weak foot (Morton 1927) may be n
In particular the short, the adducted and the hypermobile first metat

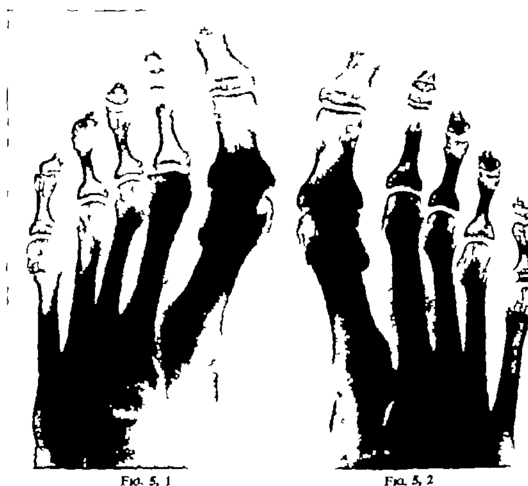


Fig. 5, 1 Fig. 5, 2

Etiology of Freiberg's Infraction

Radiographs of the feet of girl aged 16 (J O., case MT69 Table IV). Fig. 5, 1 Left. Freib infraction (Stage III) of second metatarsal head. Fig. 5, 2. Right Thickening of shaf second metatarsal. Note that the shaft of the side which sustained Freiberg's infraction not undergone thickening.

were prominent. This is the same pattern encountered in March fracture
adults and in the less well known variety of childhood (Macpherson 19
The gross thickening of the whole shaft of the metatarsal which is a feat
of the late stages of Freiberg's infraction is most probably the response
the same stimulus which in different circumstances produces the extremes
a March fracture or a mere gradual strengthening of the bone (Figs 5, 1 a
5 2) If a stress fracture is the failure of remodelling in the fourth dimension



Fig. 5, 3

Structurally Weak Feet showing Combination of Freiberg's Infraction with March Fracture

Fig. 5, 3

Freiberg's infraction (Stage V) of second with March fracture of adjacent third.

Figs. 5, 4 and 5, 5

Freiberg's infraction (Stage V) of third (Fig. 5, 4) with March fracture of opposite second (Fig. 5, 5)



Fig. 5, 4



Fig. 5, 5

—time it does not occur readily in a metatarsal of normal shape and constitution in a foot of normal shape and constitution but it can occur in exceptional circumstances It is not without significance that two patients were already under observation with symptoms of foot strain when the condition developed and that two adults developed March fractures one of the adjacent metatarsal (Fig 5, 3) and one in the



Fig. 5, 6
Pathology of Freiberg's Infraction
(Stage I)
Orientation The hook has been inserted into the fracture line and is pulling the articular surface distally Note (1) Dark-coloured living bone proximal to the epiphyseal line (2) Light-coloured ischaemic bone of epiphysis, (3) White crumbling fragments of dead bone in depths of fracture

opposite foot (Figs. 5, 4 and 5, 5) nor a coincidence that the example of a weak foot in an article on March fracture should show a Freiberg s infraction labelled osteoarthritis of metatarso phalangeal joint (Dodd 1933) It is thus difficult to escape the conclusion that both conditions have the same basis namely the structurally weak foot. But if both lesions involve fracture there is an essential difference between them March fracture involves bone with a blood supply Freiberg s infraction involves bone devoid of or at least deficient in blood supply

ISCHAEMIA OF EPIPHYSIS, RELATIVE OR ABSOLUTE

The operative reparative measures instituted in Freiberg's infraction have given the opportunity to study an example of a juvenile osteochondrosis both macroscopically and microscopically at an early stage of development The surgical pathology followed such a constant pattern that it has been possible to establish the nature of the changes with some precision

It is clear that the morbid anatomy of the juvenile osteochondroses bears little relation in time to the symptoms or to what has been considered to be the early radiological changes Axhausen (1923) recorded a case in which the whole epiphysis was necrotic before radiological examination demonstrated any abnormality and before there was any evidence of fracture Even the experience of operating within two weeks of the first symptom (A. W female, aged 12, case MT74 Table IV) failed to establish a relationship in time between total ischaemia and the onset of symptoms or of the fracture and the onset of symptoms. Furthermore, radiographs of the case in question showed no alteration in density nor of trabecular pattern It was evident that the epiphysis has been dead for some time and the fracture present for some time certainly longer than two weeks Moreover the fracture had taken place in an epiphysis so ischaemic that no haemorrhage had occurred into the joint (Figs 5, 6 to 5, 9 and 5, 10)

But at the same stage the synovial membrane is sometimes pigmented indicating a previous haemarthrosis. It would thus appear that at some time in the natural course of events haemorrhage can take place into the joint Whether it is the result of the fracture or from some other incident was not determined But it is probable that it occurs at the time of the fracture. Ischaemia is relative the epiphysis is not necessarily completely devoid of blood supply even if it is insufficient to maintain nutrition in the circumstances of the stress placed upon it or for osteogenesis. We must accept the concept of relative ischaemia just as we must accept the concept of relative stress It is the disrelation between the demands of weight-bearing and the static capacity for weight-bearing.

The blood supply of the unclosed epiphysis of childhood and that of the metaphysis are almost entirely separate If the epiphyseal vessels are affected by spasm embolus or thrombosis from whatever cause the collateral circulation from the metaphysis is insufficient to maintain nutrition It is of significance that only those parts with soft tissue attachment that is to say the projections on either side of the potential loose body (Figs 5, 14 and 5 15) appear to remain alive What has not been explained is why ischaemic epiphyseal necrosis whether of the total epiphysis as in Freiberg's infraction, or of a peripheral segment as in osteochondritis dissecans of the

knee should occur as it most certainly does at a particular age. The explanation may lie in the reference to skeletal growth and muscular development on page 8 It is not unlikely that epiphyseal growth and blood supply bear a similar relationship blood vessels do not grow at the same rate as the bone they supply Longitudinal growth could even narrow the lumen of a vessel by the simple act of stretching; and is not a toe of exceptional length a common finding It thus appears that at certain periods, and the first half of the second decade is the one in question the vascular supply of the epiphysis of the metatarsal head is critical The internal trauma inherent in a structurally weak foot can tip the balance in favour of ischaemia.



FIG. 5, 7
Pathology of Freiberg's Infraction
Section of epiphyseal plate with bone from metaphysis and epiphysis from case at Stage II (S. L., female, aged 12, MT71 Table IV). ×7

SIMILARITY TO OSTEOCHONDRITIS DISSECANS

Observations at operation on those cases in which reparative measures were attempted and in which the pathological anatomy was recognisable confirm the similarity between this condition and the local lesion in osteochondritis dissecans of the knee joint. The radiological similarity was pointed out by Köhler as early as 1920 Freiberg s infraction differs only in consisting of a much larger proportion of the total joint surface. If the pathological anatomy involves virtually the whole head of the metatarsal and Juvenile osteochondritis dissecans of the knee but a small proportion of the total epiphysis both lesions have been shown to be determined by interruption of blood supply

There are other points of similarity both begin between ten and fifteen both may be bilateral. If the etiology is correct, the fact that the majority of patients are female is not surprising so are the majority of foot troubles of similar origin *i e* hallux valgus Even March fractures in civil practice are more common in the female. The sex incidence and the location of the lesion produced is determined by stress and the particular mechanical circumstances of the joint involved It is clear that growing bone is physiologically weak.



Fig. 5, 8
Pathology of Freiberg's Infraction
Section from metaphysis showing trabeculae of live bone containing osteocytes and surrounded by normal fatty tissue. ×90 High power of Fig. 5, 7



Fig. 5, 9
Pathology of Freiberg's Infraction
Section from epiphysis showing trabeculae of dead bone containing no osteocytes and surrounded by fibrous marrow tissue ×90 High power of Fig. 5, 7

If at the time of rapid growth a static imbalance occurs resulting either from increased stress or strain, a fracture takes place in the vulnerable subchondral zone of an epiphysis rendered vulnerable as a result of ischaemia It is not a fracture separating dead from living bone It is a fracture within an epiphysis already deficient or devoid of blood supply It seems justifiable therefore to conclude of Freiberg s infraction that not only is the pathological anatomy the same as osteochondritis dissecans but like certain varieties of osteochondritis dissecans it is a form of fatigue fracture (Smillie 1956)

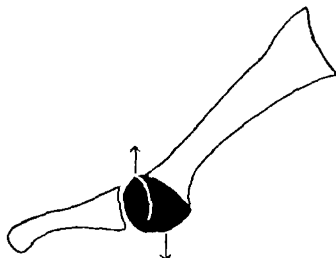


FIG 5, 10

Etiology and Pathology of Freiberg's Infraction

Diagrammatic representation. The forces responsible for the ischaemia of the epiphysis are responsible for the fatigue fracture in the dead bone

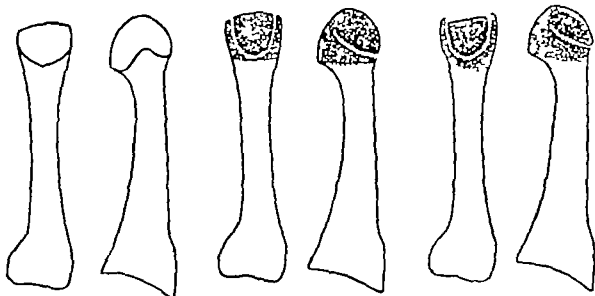
Nature of Infraction. The fracture imposed on the ischaemic epiphysis follows the pattern of osteochondritis dissecans lesions elsewhere in that it is open on one aspect, in this instance the dorsal, and closed on the other the plantar aspect. The isthmus of plantar cartilage remains intact for some considerable time possibly years, before it gives-way finally leaving a central loose body free within the joint or compressed into the metatarsal head.

Attempts have been made to reproduce the fracture experimentally on the cadaveric joint (Braddock 1959) The results although interesting and the subject of reference in relation to the hip (page 110) are unacceptable the forces applied do not obtain in natural circumstances and the injury inflicted on the articular surface bears no relationship to the known pathological anatomy of the lesion of Freiberg s infraction.

The fracture in the initial stages is no more than a narrow fissure, without reaction in ischaemic bone. It is a fatigue fracture produced by the same forces responsible for the ischaemia. It results from a shearing strain or tangential force applied to the articular surface in a similar manner to the other varieties of osteochondritis dissecans (Fig. 5, 10)

SIMILARITY TO PERTHES' DISEASE

Many writers ranging from Axhausen (1923) to Burrows (1950) have seen a relationship between Freiberg s infraction and Perthes disease. It



Pathological Anatomy Diagrammatic Representation of Stages

Fig. 5, 11
Normal metatarsal showing the extent of the articular cartilage

Fig. 5 12
Stage I A fissure develops close to the margin of the articular surface

Fig. 5, 13
Stage II Absorption of bone has taken place and the potential loose body begins to sink into the head altering the contour of the articular surface.

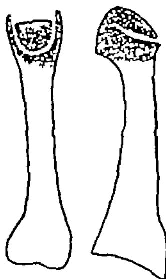


Fig 5, 14
Stage III Further absorption has occurred and the central portion sinks into the head leaving projections on either side The plantar articular cartilage remains intact.

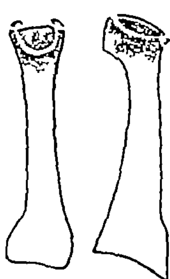


Fig. 5, 15
Stage IV The plantar isthmus of articular cartilage has given-way and the loose body separated. Fractures of the lateral and dorsal projections have occurred.

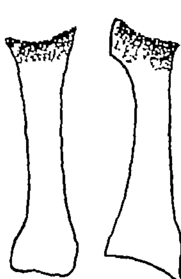


Fig. 5, 16
Stage V Final stage of flattening and deformity The remaining plantar portion of the head retains the normal contour

seems probable from the experience of this series that they are the most closely related of the so-called osteochondroses by comparison with the localised lesions elsewhere. Both involve the entire epiphysis But a fracture *exactly comparable with Freiberg's infraction does not occur in the hip* because the shape of the head does not permit the application of a shearing stress to a convex surface (see page 109)

It is probable that if an accurate clinical diagnosis was possible in the head of the femur such as is possible in the metatarsal head, and in the complete absence of radiological abnormality the same findings as have been recorded namely absence of blood supply would be noted.

One patient (MT45 Table IV) suffered from both conditions.

PATHOLOGICAL ANATOMY

In this series the progress of the condition through the various stages followed a constant pattern. There was no evidence of two or more forms of the disease The varying and contradictory statements in contemporary textbooks are probably due to the different appearances of the radiographs at the different stages of development and the fallacies inherent in the interpretation of radiographs of bone in terms of pathological anatomy

Five stages, based on the pathological anatomy rather than the radiographs (Axhausen 1923) can be recognised

Stage I. The first opportunity to observe the earliest stage of the lesion occurred in a girl aged 14 (case MT22, Table IV) who had been treated by operation for the same condition on the Right side, but at Stage II nine months previously She reported three weeks after the onset of symptoms on the Left side The parents were informed that at this early stage the disease would almost certainly heal by immobilisation alone but they sought in view of their experience of the Right side what appeared the certainty of success by a repetition of operative measures

At operation, a fissure close to the margin of the articular cartilage was present (Fig. 5, 11) It was difficult to find, without visible reaction and so narrow that little more than a knife blade could be inserted. Access to the depth of the fracture by the method to be described, gave the impression of sclerosis of apposing cancellous surfaces It was decided in view of the early nature and circumstances of the case, that it was unjustifiable to cause other than minimal disturbance to the part but the operation confirmed with certainty the presence of ischaemia and the existence of a fracture without visible signs of reaction within the ischaemic bone This case provided also the explanation of the failure of the radiographs to reveal the lesion at this stage it has been shown experimentally that a space of at least one millimetre

between the fragments of a fracture is necessary before the line of separation can be identified radiologically (Lachmann 1938) The finding, in relation to Freiberg's infraction in particular has been confirmed (Braddock 1959)

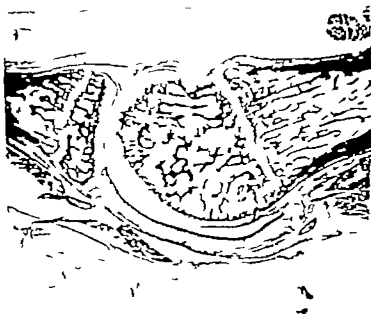


FIG. 5, 17
Section of normal second metatarso-phalangeal joint of female aged 13 to show epiphyseal plate of metatarsal and relationship of synovial membrane to epiphysis.

Stage II. Absorption of cancellous tissue has occurred on the proximal side of the lesion so that the dorsum of the articular cartilage begins to sink beneath the level of the articular margins, hinging on the intact cartilage at the plantar aspect. The bone on the proximal side is dense that on the distal side is dead (Fig. 5, 12)

Spontaneous healing There is evidence that natural healing is possible in the early stages of the disease Cases are encountered in which healing appears to have occurred at a relatively early stage as shown by the minimal deformity in the radiograph in the final stage. The experience gained in operating on cases at, in particular Stage II suggests that the method by which spontaneous healing occurs is the attainment of a blood supply by the distal fragment from the synovial membrane on the dorsal aspect of the joint. The evidence favouring this route is the absorption of cartilage and proliferation of bone seen on the dorsal margin of the distal aspect of the fracture line Further the fracture line cannot be seen at operation until synovial membrane has been divided and this synovial membrane appears to be attached to the margin where absorption of cartilage has taken place (Figs. 5, 17 and 5, 18)

Stage III. Further absorption has occurred and the main portion of the articular cartilage sunk so far into the head that sizeable projections remain on either side The small exostoses on the dorsum of the proximal side may have fractured but retain soft tissue attachments The isthmus of articular cartilage on the plantar aspect is intact (Fig. 5, 13)



Fig. 5, 18 *Fig. 5, 19* *Fig. 5, 20* *Fig. 5, 21*

Spontaneous Healing in Freiberg's Infraction

Spontaneous healing may occur at Stage II as a result of the relationship of the synovial membrane to the epiphyseal head (Fig. 5, 11) which permits the bone distal to the fracture line to obtain a blood supply No loose body separates and the resulting deformity may be minimal (Figs. 5, 18 and 5, 19) (A. G female, aged 5_, MT75 Table IV) or moderate (Figs. 5, 20 and 5 21) (M P., female, aged 41 MT79 Table IV)

Stage IV The main portion of the articular surface has sunk so far that the plantar hinge has finally given way The projections on either side have fractured and have with the soft tissue intact, become folded over the central loose body (Fig. 5 15) The base of the phalanx is of normal contour but the articular surface is fissured and distorted.

Stage V The final state is characterised by marked flattening and deformity of the metatarsal head. Only the plantar aspect, where the final

isthmus of cartilage fractured retains the original contour The loose body is much reduced in size or may have disappeared apparently ground between the incongruous joint surfaces The shaft of the metatarsal is thickened and dense (Fig 5, 16)

Thickening of the metatarsal shaft Thickening of the metatarsal while most marked in the final state (Fig. 5, 3) may be seen at any stage and may be noted even before the initial lesion occurs Sometimes re-modelling of the neck may be so localised that it looks almost like the callus seen in a March fracture.

The ischaemia of the epiphysis in Perthes disease is known to promote broadening or growth in circumference of the neck of the femur It is probably the same influence which is responsible for the increase in circumference in the neck of the metatarsal in addition to the stimulus to strengthen the shaft to withstand the strain of weight-bearing It is the combination of these influences to say nothing of the known capacity of the metatarsals to produce callus, which is responsible for the very marked increase in circumference which is the common finding.

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Stage III. Further absorption has occurred and the main portion of the articular cartilage sunk so far into the head that sizeable projections remain on either side The small exostoses on the dorsum of the proximal side may have fractured but retain soft tissue attachments The isthmus of articular cartilage on the plantar aspect is intact (Fig. 5, 13)



FIG. 5 18 FIG 5, 19 FIG. 5, 20 FIG. 5, 21

Spontaneous Healing in Freiberg's Infraction

Spontaneous healing may occur at Stage II as a result of the relationship of the synovial membrane to the epiphyseal head (Fig. 5, 11) which permits the bone distal to the fracture line to obtain a blood supply No loose body separates and the resulting deformity may be minimal (Figs 5, 18 and 5, 19) (A G., female, aged 52, MT75 Table IV), or moderate (Figs. 5, 20 and 5, 21) (M P female, aged 41 MT79 Table IV).

Stage IV The main portion of the articular surface has sunk so far that the plantar hinge has finally given-way The projections on either side have fractured and have with the soft tissue intact, become folded over the central loose body (Fig. 5 15) The base of the phalanx is of normal contour but the articular surface is fissured and distorted

Stage V The final state is characterised by marked flattening and deformity of the metatarsal head Only the plantar aspect, where the final

isthmus of cartilage fractured retains the original contour The loose body is much reduced in size or may have disappeared apparently ground between the incongruous joint surfaces. The shaft of the metatarsal is thickened and dense (Fig 5, 16)

Thickening of the metatarsal shaft Thickening of the metatarsal, while most marked in the final state (Fig. 5, 3) may be seen at any stage and may be noted even before the initial lesion occurs. Sometimes re-modelling of the neck may be so localised that it looks almost like the callus seen in a March fracture

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CHAPTER 6

ELBOW JOINT

CASES under review—In the series of forty-six patients (Table V page 198) *were forty-one males and five females. In three all males, both elbow* joints were affected. In the unilateral cases, the right side was involved in thirty instances, the left in thirteen. The condition thus affected males eight times more often than females (*cf* Freiberg s infraction) The right elbow was affected nearly three times more often than the left.

Comparison with other series.—The comprehensive clinical study of thirty-eight cases from the records of hospitals in the Liverpool area of England (Roberts and Hughes 1950) which is outstanding in the literature of osteochondritis dissecans in English and to which reference will be made on many occasions, forms a useful basis for comparison with this series of similar size The cases, like those of Roberts and Hughes, were what remained when loose bodies of doubtful origin had been eliminated. But the yardstick of definition differed. In the present series cases were retained if the site of origin was known with certainty

Age of onset.—In the Roberts and Hughes series the youngest patient was aged 11 the highest incidence at 14 to 15 and an occasional case of 19 to 20 Other writers report a similar range of ages (Löhr 1930 16 to 20 *von Staa 1930 15 to 22 Meyer Wildisen 1932, 14 to 18) In this series* the ages ranged widely between 14 and 55 The records are those of patients admitted to hospital. This explains the higher ages and the preponderance of cases with loose bodies in the joint.

Sex.—In the Roberts and Hughes series thirty-five of the thirty-eight were males. Earlier papers record 85 to 90 per cent of cases (Kappis 1920 von Staa 1930 von Tempsky 1930)

In this series the ratio is similar there were five females in the forty-six. In the five is included a case which may have been a marginal fracture of the head of the radius.

Side.—In the Roberts and Hughes series the right elbow was involved on twenty-seven instances the left in five In six cases the condition was bilateral The same predilection for the right side was noted by previous writers (Kappis 1920 Schirmer 1925 Christensen 1930 von Tempsky

1930) This series provides confirmation of these findings That the tendency is less accentuated sixteen left elbows in forty-six may be due to the high proportion of coal miners involved

NATURE OF LESION

The experience of observing lesions at an early stage of development and, at a later stage, of the site from which loose bodies have separated suggests that in a large proportion of cases the pathology differs from that encountered in the knee joint.

In the elbow there is seldom evidence of a deep underlying area of ischaemic bone such as is present in the knee joint. The lesion gives the impression that the surface articular cartilage received the damage first and that it was only when the cartilage became lacerated or worn away that the bone was affected. In other words, instead of occurring from within outwards as is the typical osteochondritis dissecans pattern, it occurred from without inwards.

The wide variety of radiological appearances which have been described (King 1932 Roberts and Hughes 1950) confirm these observations What is seen is patchy decalcification with ill-defined limits, or more commonly and probably representing a later stage of development an appearance like multiple cysts (Fig. 6, 1) The radiological finding of an island of subchondral bone surrounded by rarefaction set within a zone of sclerosis, which is considered to be typical of osteochondritis dissecans elsewhere is less frequently encountered (Fig. 6, 18)

An explanation is necessary a simple one is offered. The appearances described are consistent with the different stages of the reaction of normal bone to the loss of cartilaginous covering More should not be read into radiographs than is justified by the pathological anatomy of the lesion

ETIOLOGY ENDOGENOUS MECHANICAL FACTOR

Reference has been made in general terms to the delicate relationship between the components of joints which must exist or mechanical upsets would be commonplace (page 38) An example was cited in the hip joint If this theory is correct, lesions of endogenous mechanical origin might reasonably be expected to be most common in joints like the knee and elbow which appear to be of most mechanical complexity The preponderance of cases in which these two joints are involved would seem to confirm the suggestion.

In the elbow osteochondritis dissecans is not confined to the capitellum and independent of the head of the radius (Figs 6, 1 and 6, 10) The lesion occurs as a result of contact between these two components of the joint (Figs 6, 5 to 6, 8) The etiological factors which make such contact possible are the points at issue. It is significant that observations at operation in cases of fracture of the head of the radius show that almost invariably an injury has



Fig. 6, 1



Fig. 6, 2

Bilateral Osteochondritis Dissecans of the Elbow

The lesion is not confined to the capitellum. In this example the outstanding lesion on one side is in the capitellum (Fig. 6, 1) on the other in the head of radius (Fig. 6, 2). Note radiological features of lesion in capitellum.

been inflicted on the capitellum in the course of fracture. The site and type of injury varies. There may be nothing more than an indentation of the articular surface or partial separation of cartilage in the form of a flap or complete separation of cartilage from the antero-inferior aspect of the capitellum to an area of half an inch square. When complete separation takes place it appears to occur through the surface layers of bone, leaving a raw surface, rather than between cartilage and bone.

An example of the proof of contact in osteochondritis dissecans and of the gross pathological anatomy of the opposing lesions, is cited in the operative findings of this case

On opening the joint (J C., male, aged 16, E39 Table V) the outstanding features were the size of the head of the radius and the closeness of the relationship

to the capitellum. The lesion was hidden by the proximity of the radius and the full extent was evident only after excision of the head Not only was there a bare area of bone completely devoid of articular cartilage but there were large loose flaps of cartilage on both anterior and posterior aspects. When these flaps had been excised the lesion was seen to extend to at least two-thirds of the total area of capitellum The line of cleavage lay in the superficial layers of the bone and adhering to the larger flap of cartilage were small fragments of cancellous tissue



FIG. 6, 3

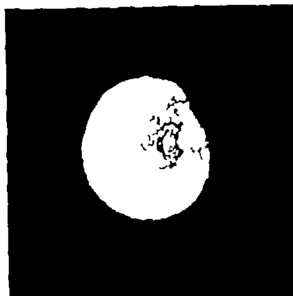


FIG. 6, 4

The lesion is not confined to the capitellum (Fig 6, 3) The head of the radius from the same case showing the lesion which opposed the site in the capitellum (Fig. 6, 4) (M R., female aged 15 E34 Table V)

Examination of the head of the radius during the operation showed irregular hypertrophy in that the lateral aspect appeared much larger than the medial The head appeared to be set on the shaft at a slight angle so that it rotated in an eccentric manner

On the anterior aspect of the edge of the concavity an area of articular cartilage was raised from the bone almost in the form of a blister When a sagittal section was made through the raised area it was seen that the articular cartilage concerned was separated from bone in an area of approximately three mm. square. There was no communication with the surface of the articular cartilage (Fig 6, 10)

There can be little doubt from examination of the opposing lesions in a case such as that described that the lesion on the capitellum is caused by contact with the head of the radius and that the lesion within the articular cartilage of the head of the radius is produced in the course of producing the lesion in the capitellum



Fig. 6, 5



Fig. 6, 6

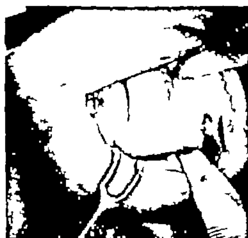


Fig. 6, 7

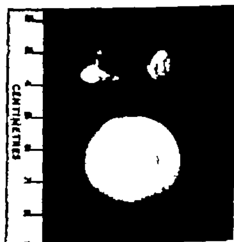


Fig. 6, 8

Etiology of Osteochondritis Dissecans of Elbow Joint

Figs. 6, 5 and 6, 6. Radiographs to show shape, conformation and relationship of head of radius to humerus. Fig. 6, 7. There is direct contact between head of radius and lesion in capitellum. Fig. 6, 8. Head of radius and the potential loose bodies from the opposing lesion in capitellum. (D. McL., male, age 17. E43. Table V.)



Fig 6, 9



Fig 6, 10



Fig. 6, 11

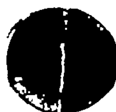


Fig 6, 12



Fig 6, 13

Figs. 6, 9 to 6, 13

Lesion involving articular cartilage of antero-inferior aspect of capitellum (Fig. 6, 9). Head of radius showing horizontal cleavage lesion in cartilage at point of contact with capitellum (Fig. 6, 10) Radiograph showing characteristic cyst-like appearance in bone which is the reaction to overlying lesion in cartilage (Fig. 6, 11) Radiographs of the excised head to show variation in the thickness of articular cartilage Lead shot has been inserted to outline the horizontal cleavage lesion (Figs. 6, 1– and 6, 13). (J C., male aged 16, E39 Table V)

It is of particular interest that the lesion in the articular cartilage head of the radius should take the "horizontal cleavage" form It is of lesion found in structure subject to rotation strains such as the n of the knee joint where it is clearly related to the screw home movemei page 20) The head of the radius a rotating structure apparently suff same lesion when subjected to the trauma of contact with the capitellun





FIG. 6, 14 FIG. 6, 15

Lesion in capitellum with radiological (Fig. 6, 14) and physical characteristics (Fig. 6, osteochondritis dissecans in other joints. Note large bone element in fragment (Fig. and site of lesion towards anterior aspect of capitellum (Fig. 6, 15) (J M male, a E33 Table V)

FEATURES RELATING TO GROWTH AND BLOOD SUPPL

BLOOD SUPPLY OF DISTAL END OF HUMERUS

Investigations by contrast media on the internal vascular system c distal end of the humerus in cadavers of a wide range of ages (Haral 1957) have suggested that (1) as long as the nucleus of ossification c capitellum lies isolated in the epiphyseal cartilage it appears to recei blood supply by a few vessels entering from behind and forming inte munications in the nucleus At this stage of development the vessels c nucleus are not in communication with the other parts of the distal end o humerus (2) the nucleus of ossification of the capitellum extends int

radial part of the epiphyseal cartilage of the trochlea Part of the trochlea is thus ossified from the nucleus of the capitellum (3) vessels are seen to extend to the future site of the nucleus (nuclei) of ossification of the trochlea before the bone salts deposited there have reached a concentration high enough to be demonstrable in a radiograph (4) the topography of the vascular system forming in the capitellum during the period of ossification persists practically unchanged in the adult bone (5) after ossification of the cartilage between the various nuclei and of the epiphyseal plate the blood vessels of the diaphysis metaphysis and epiphysis intercommunicate

These conclusions of Haraldsson would appear to convey that no special circumstances of vascular topography obtain in either youth or maturity which explain the localisation of the lesion to the capitellum. If the argument which has been developed regarding the relationship of the head of the radius to the lesion is correct, it would have been surprising if the outcome of such investigations had been otherwise. But if local ischaemia of the capitellum explained by the arrangement of the internal blood supply of the distal end of the humerus has been eliminated the possible factor of ischaemia in general has not been excluded.

ENLARGEMENT OF HEAD OF RADIUS

Apparent hypertrophy of the head of the radius was a feature of almost every patient for whom accurate clinical records were available. Opinions differ regarding the proportion of cases involved. Löhr (1930) considered all were affected Roberts and Hughes found that half of their series showed the feature in unmistakable degree No figures can be given for the series under review operative records were frequently incomplete radiographs unreliable in the presence of osteoarthritis (Figs. 6, 16 and 6, 17)

The enlargement is not uniformly distributed but affects the posterolateral aspect of the bone thus producing the effect of eccentricity on rotation Roberts and Hughes stated that the enlargement may occur either before or after closure of the epiphysis but thought in contradistinction to Löhr that it was unlikely to be related to a disturbance at the epiphyseal plate They pointed out that growth at the plate is longitudinal in character whereas the epiphysis grows by circumferential accretion. It appears however that such a distinction cannot be drawn in explaining the abnormally close relationship between head of radius and capitellum which can undoubtedly exist even before epiphyseal maturity is complete (Figs. 6, 5 and 6, 6)

No acceptable explanation has been offered for the longitudinal or circumferential enlargement. Roberts and Hughes have pointed out that such enlargement is not confined to cases of osteochondritis dissecans but occurs

from other causes mentioning in particular T-shaped fractures and subluxation of the head An example of the latter condition that the lesion is of mechanical origin and due to impingement of head of radius against the capitellum and that it is related to the size, shape and mechanics of the head of the radius, is shown by the following case

The patient (D McL., male, aged 17 E43 Table V) presented with symptoms of pain in the right elbow together with loss of extension and limitation of both supination and pronation. There was a history that 10 years previously that is to say at the age of 7 he received an injury to the elbow but had no trouble until two years ago The radiological changes seen in the capitellum were clearly those of osteochondritis dissecans It was noticeable that the head of the radius, as well as being large and irregular was displaced anteriorly It thus seemed likely that at the age of 7 he had sustained an anterior dislocation.

The point of particular interest, in relation to the etiology of osteochondritis dissecans was the fact that this irregular displaced head of radius had produced in the capitellum a lesion indistinguishable from osteochondritis dissecans. The lesion from which two loose bodies were removed corresponded exactly to contact with the head of the radius in extension and supination It was clearly produced by the head of the radius and when it was excised a considerable increase in extension supination and pronation occurred It appeared significant that the lesion in the capitellum was of much greater magnitude than that on the head of the radius even although the basic mechanical error lay in the head of the radius.

An example of enlargement of the head of the radius following fracture of the olecranon, and once again, of the effect of bringing head of radius and capitellum into abnormally close relationship is seen in the case of

J C., male, aged 25 who one year previously sustained a fracture of the olecranon which because of damage to the overlying skin could not be subjected to operation fibrous union ensued Five months later in a further accident, the fragment was redisplaced. On this occasion operation was possible and reduction and internal fixation effected but the loss of bone tissue brought head of radius into closer contact This patient, six months later not only showed enlargement of the head of radius but the radiological appearances of osteochondritis in the capitellum

If it is justifiable to draw conclusions from the foregoing, enlargement or hypertrophy of the head of the radius is cause or part cause, in the etiology of the lesion in the capitellum Any alteration in the delicate mechanics, for a wide variety of reasons, of the components of the joint incur the liability to a contact lesion Enlargement of the head of the radius following major trauma is a phenomenon which can be accepted It remains to be explained why it occurs in youth Several possibilities arise (1) that it is a manifestation of ischaemia Excessive growth of enveloping cartilage could as has been suggested already be a manifestation of relative ischaemia

in the underlying bone (2) that during a period of relative ischaemia contact becomes possible This, by stimulus increases the growth of the underlying bone. It could thus be a situation where cause and effect are interchangeable. In this regard it is possibly significant that in the later stages of the disease it is the bone element of the head which is enlarged The cartilage is then of a dusky pink colour presumably as a result of hyperaemia in the underlying bone (3) that size and possibly relationship to capitellum is related to epiphyseal prematurity at the distal end of the humerus.





FIG. 6, 16 FIG 6, 17

Enlargement of Head of Radius in Osteochondritis Dissecans of Elbow

In the late stages, where there is superimposed osteoarthritis, it is difficult to tell cause from effect. Fig. 6, 16 shows extensive lesion of capitellum with large opposing radial head. There is a loose body in the olecranon fossa (V B., male aged 31 E28 Table V) Fig. 6, 17 shows large head of radius with hypertrophic changes. There is a loose body between neck of radius and ulna (E. McL., male, aged 35 E2., Table V)

EPIPHYSEAL PREMATURITY

Löhr (1930) who has studied epiphyseal changes in relation to osteochondritis dissecans considers that there is premature fusion of the lower humeral and upper radial epiphyses In contradistinction to the normal sequence of events, fusion begins on the lateral aspect and proceeds medially and that these changes occur after the first sign of a lesion in the capitellum Roberts and Hughes point out that fusion of the lower humeral epiphysis is usually well advanced at 15 years The opportunity to confirm such disturbances of epiphyseal growth is limited by the age at which patients are first encountered They record three instances of premature closure including a

case which showed marked difference between the sides with enlargemen the head of the radius on the more mature side but no lesion when first s Five years later the mature joint showed radiological changes compan with Fig. 6, 1 indicating a contact lesion of articular cartilage exposing un lying bone.

These observations appear contradictory and do not distinguish cause f effect but they confirm the possibility of abnormality of shape and siz joint components by alteration of the pattern of epiphyseal fusion. If example the radial epiphysis remains open when the humeral epiphyses h prematurely closed, the possibility of a contact lesion would appear to increased

ETIOLOGY DYSOSTOTIC FACTOR

If trauma is the principal agent in osteochondritis dissecans of the elb and frequently the only obvious agent, it is by no means always so dysostotic constitutional factor is sometime evidence. But if an anomaly of ossification been shown to be the precursor of Juve osteochondritis dissecans in the knee it probably less often the precursor of a lesion the elbow joint. Multipolar ossification osteochondritis in the capitellum usu heals spontaneously if it is only for the rea that the area affected is not subjected to strain of weight bearing. That no example of anomaly of ossification is known to have veloped osteochondritis dissecans in the per under review does not mean that the possibi does not exist. Even the established lesion pass relatively unnoticed for decades.



FIG 6 18
Radiological features of osteochondritis dissecans of elbow Lesion in capitellum with appearance similar to lesions at other sites (R P male, aged 15 E45 Table V) Compare epiphyseal maturity with Fig. 6, 3 (M R female, aged 15 E34 Table VI.

The following example is a case in wh the lesion may have arisen in an anomaly ossification but in any event illustrates dysostotic factor

The patient (R P., male aged 15 E45 Ta V) gave a history that while swimming six we previously he developed pain in the left elb When a radiograph was taken there was a well marked lesion in the capitellum going into his history in detail it transpired that he had received treatment two an half years previously for a greenstick fracture at the lower end of the radius sustain

in a fall on the outstretched hand The possibility arose therefore that the lesion in the capitellum was due to impingement between head of radius and humerus in this accident. When the original radiographs were found they showed that the osteochondritis dissecans lesion was already present in the capitellum An anomaly of ossification, consisting of multipolar ossification was present in the trochlea The interesting feature of the case, from the dysostotic constitutional factor aspect, was his small stature he was 5 ft in height at the age of 15 (Fig. 6, 18)

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CHAPTER 7

ANKLE JOINT

CASES under review —The patients who comprise the series varied widely in age between fifteen and seventy-two (Table VI) There were twice as many females as males. These figures contrast with a series of similar size (Ray and Coughlin 1947) in which there was a marked predominance of males ranging from nineteen to thirty four with an average age of twenty-four But that series was selected occupations, sex and age were determined by war No direct comparison is possible. In the unselected cases under considera tion it was thought a not unreasonable inference, in spite of the small numbers concerned that the preponderance of females was influenced by the use of high heels, and the tendency to insta bility which results. All the true[1] lesions in female patients were located on the medial aspect (Fig. 7, 1) The three lateral lesions encountered occurred in males.



FIG. 7 1

Osteochondritis Dissecans of Talus

Typical radiological lesion on supra-medial aspect.

CAUSE AND NATURE OF LESION

If the Tables which relate to the knee, metatarso-phalangeal and elbow joints (III IV and V) indicate that osteochondritis dissecans frequently arises in the middle years of the second decade and exists in Juvenile and Adult forms, there was no evidence that such circumstances obtain in the ankle joint only the Adult variety was encountered

The condition is uncommon and experience limited No relationship could be seen to any factor of constitutional or hormonal origin except in so far as such influences may have determined the shape of the talus and the form of the joint (page 37) It was considered that repeated minor traumata

[1] The last c se in T ble VI is an osteoarticular fracture

was responsible for local ischaemia in the typical osteochondritis pattern and that superimposed on ischaemic bone is the fracture (Figs 7, 2 to 7, 6)

That the condition is of traumatic origin is confirmed by the fact that comparable lesions, on both medial and lateral aspects of the talus were encountered as a result of single acts of violence (Fig. 7, 1)

An example is cited in the case of M S., a female, aged 23 who in a fall downstairs, sustained a gross inversion strain The radiograph showed a fragment at the supra lateral angle, containing more bone from the superior than from the lateral surface, lying upside down at the site of the lesion This finding would suggest that the osteo-articular fracture had occurred by an inversion mechanism even if the history had not been available from the patient.

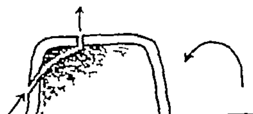


FIG. 7 2
Osteochondritis Dissecans of Talus
Diagrammatic representation of the mechanism and form of osteochondral fracture produced by inversion or eversion mechanism

At operation performed through a straight antero-lateral incision because of the existing rupture of the anterior band of the lateral ligament, the defect was found to be located on the anterior half of the bone and was of recent origin. The fragment was quite free and was replaced in the fracture site without preliminary preparation and fixed with a nail

At one stage in the study the possibility that the lesion was no more than an undetected osteochondral fracture was considered The experience of operating on the fracture within ischaemic bone with intact enveloping articular cartilage confirmed the pathology to be identical with that described elsewhere If the condition is more common in women and if the site of the lesion on the medial aspect of the talus results from an inversion mechanism the location towards the posterior aspect of the bone is determined by the use of high heels.

An attempt has been made throughout this work to distinguish between osteochondral fractures, from a single incident of violence, and osteochondritis dissecans Known osteochondral fractures have been excluded from the Tables. Certain cases have been included, and noted as such when doubt was cast on their origin It should be recorded that an exception has been made in Table VI two cases (A12 and A16) were undoubtedly osteochondral fractures Not all observers have drawn so fine a distinction Ray and Coughlin (1947) for example, in attributing osteochondritis dissecans of the ankle to trauma considered either a single recognised episode or repeated minor unnoticed traumata to be responsible They summarised the patho-



FIG 7 3



FIG. 7 4



FIG 7 5



FIG. 7 6

Osteochondritis Dissecans of Talus

FIGS 7 3 and 7 4 Lesion on supra-medial aspect (Fig. 7, 3). Fissure in articular cartilag (Fig. 7 4) Point of dissector is between bone element and body of talus. Note pedunculate flaps of articular cartilage and size of fragment of ischaemic bone (D T., male, aged 2 A11 Table VI) FIG 7 5 Lesion on supra-medial aspect. Note hinged flap of articul cartilage with underlying ischaemic bone (H J., female, aged 45 A9 Table VI) FIG. 7 Lesion on he medial aspect. The cartilage is intact antero-laterally The fissure is poster medially rew in medial malleolus and method of retraction with twisted gauze swa (G W., male, aged 26, A15 Table VI)

logical anatomy with considerable accuracy when they stated that such trauma produced localised vascular diminution leading to avascular separation of the loose fragment of cartilage and subchondral bone

Reference

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FIG. 7 3



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FIG. 7.3



FIG. 7.4



FIG. 7.5



FIG. 7.6

Osteochondritis Dissecans of Talus

FIGS. 7.3 and 7.4. Lesion on supra-medial aspect (Fig. 7.3). Fissure in articular cartilag[e] (Fig. 7.4). Point of dissector is between bone element and body of talus. Note pedunculate[d] flaps of articular cartilage and size of fragment of ischaemic bone. (D. T., male, aged [illegible] A11 Table VI.) FIG. 7.5. Lesion on supra-medial aspect. Note hinged flap of articul[ar] cartilage with underlying ischaemic bone. (H. J., female, aged 45. A9 Table VI.) FIG. 7.[6] Lesion on th[e] medial aspect. The cartilage is intact antero-laterally. The fissure is poster[o-] medially. [illegible] screw in medial malleolus and method of retraction with twisted gauze swa[b] (G. W. male, aged [illegible]6. A15 Table VI.)

It appears from the description illustrations, and what is recalled from cases other than those recorded here that there is a difference between the lesion in the head of the femur and elsewhere. At the classical site in the knee, and in other joints, an isthmus of articular cartilage has been described



FIG. 8, 1

Osteochondritis dissecans of hip Radiograph to show site of lesion where loss of contour indicates articular cartilage and underlying ischaemic bone have been sunk into the head. (J D., male, aged 31 H5 Table VII)

located on the opposite side of the lesion from the direction of the causative force. This is not the form encountered in the hip The cartilage outlined over a circumscribed area sinks into the head of the femur (Fig. 8, 1) The form is determined by the shape of the bone in which the lesion originates. It is not possible to apply a tangential force to the round head of the femur

CHAPTER 8

HIP JOINT

OSTEOCHONDRITIS dissecans in the form described in other joints, is rare in the hip In 1940 thirty cases only had been reported (King and Richards) The largest series added since then appears to be the eight cases of Guillemmet and Barbier (1957) There are a number of single examples (Jenkins 1958 etc) or of the type affecting multiple joints (Roberts and Hughes 1950 White 1957 etc.) This series contributed five cases The condition is probably more common than these figures indicate (see below)

Age.—The review of the recorded cases at that time (King and Richards 1940) showed a range of ages between twelve and fifty-one with an average of twenty-five Guillemmet and Barbier s eight patients fell between eleven and forty-one The five cases of this series lay between fourteen and sixty-two All that can be said from the data available is that in general the condition appears to affect young adults.

Sex.—The majority of the patients described have been males but the condition appears to be less predominantly a male affection than is Perthes disease

Side.—No information is available on the frequency with which one or other side is affected. Differences of opinion exist on bilateral involvement. King and Richards state that both hips are affected in one-third of the patients encountered. On the other hand Guilleminet and Barbier found only four in the thirty cases they reviewed In their own series of eight, none was bilateral In two of the five cases recorded in Table VII both hips were affected.

FORM OF LESION

The typical lesion involves an area of articular cartilage approximately two centimetres square on the weight-bearing area on the supra-lateral aspect of the femoral head. The fragment consists of cartilage of relatively normal appearance attached to dead bone lying within a cavity the base of which is covered with a thin layer of fibrous tissue.

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Later observers have been less certain Guilleminet and Barbier (1957) for example thought that the appearance of a capital necrosis in the latter years of childhood might be a transitional phase between Perthes disease and osteochondritis dissecans (Figs 8, 2 and 8, 3) There was the case of a child aged 6 in this series (H2, Table VII) which might fall into this category

If an anomaly of ossification is the basis for the development of Juvenile osteochondritis dissecans through the agency of trauma then the Juvenile as opposed to the Adult type, might be expected to be uncommon at all joints with the exception of knee and hip In this suggestion theory is confirmed by



FIG. 8, 4
Hip of boy aged 11 with history of osteochondritis from aged 2. Minimal deformity but radiological lesion typical of osteochondritis dissecans.

practical experience but only if it is accepted that Perthes disease of the hip is a variety of the same pathological process. The apparent rarity of osteochondritis dissecans of the hip would then be explained by the fact that it is nothing more than a localised form of Perthes disease occurring at a much later stage of development (Figs 8, 2 and 8, 3)

Reference has been made in Chapter V to the opportunity which has existed for the study of a juvenile osteochondrosis, in the form of Freiberg s infraction at an early stage of development. The similarity between the basic pathology of Freiberg s infraction and Perthes disease namely ischaemia

only pressure. The cartilage therefore sinks in the form of a depression. It is in this respect that the experiments carried out on the cadaveric metatarsal head by Braddock (1959) are of interest. The forces which he applied appear more like those likely to occur at the femoral head than to reproduce the lesion of Freiberg's infraction. It seemed significant that the lesions produced by force applied directly to the articular surface of the metatarsal head are not unlike those of osteochondritis dissecans of the hip



FIG. 8, 2 FIG. 8, 3

Bilateral Perthes' Disease

Application of multiple-layer single-exposure tomography to demonstrate different stages of the disease. *FIG. 8, 2. Left.* Early stage showing dead epiphysis (compare with early stage of Freiberg's infraction). FIG. 8, 3. Right. Later stage showing typical radiological features of osteochondritis dissecans.

It is clear that the form taken by lesions in the various sites is determined by mechanics of the joint concerned. In the hip the shape of the joint determines that the osteochondral fragment sinks into the parent bone, in direct contradistinction to other situations where it is cast into the synovial cavity as a free loose body

RELATIONSHIP TO PERTHES' DISEASE (LEGG-CALVÉ-PERTHES' DISEASE)

Magnin (1931) was at pains to distinguish between osteochondritis dissecans in the hip and Perthes' disease, stating that no relationship exists.

Later observers have been less certain Guillemınet and Barbier (1957) for example, thought that the appearance of a capital necrosis in the latter years of childhood might be a transitional phase between Perthes disease and osteochondritis dissecans (Figs 8, 2 and 8, 3) There was the case of a child aged 6 in this series (H2 Table VII) which might fall into this category

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of the entire epiphysis was stressed. It was suggested that if a clinical diagnosis was possible at the hip at the same stage as in the metatarso-phalangeal joint the same findings would be recorded The only confirmation for the suggestion exists in the radiographic increase in joint space which is seen in the early stages of Perthes disease.

The demands of bone and of articular cartilage on blood supply are so diametrically opposed that a delicate balance between them must exist if the normal thickness of articular cartilage in relation to bone is to be maintained. It is known that the presence of a blood supply is deleterious to the welfare of articular cartilage and causes absorption or thinning. On the other hand, articular cartilage, partially detached as in osteochondritis dissecans or free in the joint in the form of a loose body undergoes hypertrophy In these circumstances it is not unreasonable to suppose that articular cartilage enveloping bone the subject of ischaemia undergoes thickening.

The deformity of the head of the femur in Perthes disease does not take place while the epiphysis is ischaemic but during the process of healing. The bone is hard and does not suffer from distortion when it is devoid of blood supply but when it is undergoing revascularisation it is soft and gives-way under the pressure of weight-bearing or while lying in bed, of the muscle action involved in straight leg raising It is at this time that the overlying articular cartilage previously intact, suffers multiple fractures from the loss of support of the underlying bone (Fig. 8, 4) These circumscribed osteo-cartilaginous areas may become separated (Mroz 1932) Roberts and Hughes (1950) record three such cases with the comment that the picture is indistinguishable from osteochondritis dissecans. Ratliff (1956) has reported two cases Evans (1958) has recorded one The association has been strengthened by the case of a boy who at the age of eight had suffered Perthes disease from which after a year in hospital he made a clinical recovery At the age of twenty on a return of symptoms, he was found on radiological examination to show an area of osteochondritis dissecans which was later confirmed at operation (Jenkins 1958)

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ETIOLOGY AND PATHOLOGY SUMMARY

1 '**Osteochondritis Dissecans**' is not an entity but a number of things.
2 Two varieties **Juvenile** and **Adult**, can be distinguished
3 In each the basic pathology is ischaemia
4 In each there is an endogenous mechanical factor
5 In the Juvenile trauma is superimposed on ischaemic bone to produce the lesion
6 In the Adult trauma produces the ischaemic bone and continuing, produces the lesion
7 In the Juvenile variety the constitutional factor is enchondral dysostosis, the most common hereditary disease of the skeletal system in man.
8 Many manifestations of the dysostotic constitution can be recognised That of local importance in the etiology of osteochondritis dissecans is the tendency to the formation of accessory centres of ossification
9 Difficulty exists in determining by radiograph what constitutes a normal variant of ossification and at what stage the normal becomes the abnormal.
10 The fallacies inherent in the interpretation of radiographs of bone in terms of pathological anatomy have contributed to the confusion and contradictions of the past
11 It is considered unlikely that the established lesion of osteochondritis dissecans heals spontaneously possibly not even with rest.
12 Cases reported to have healed spontaneously were anomalies of ossification, unrecognised as such, which would probably have disappeared in any event.
13 Anomalies of ossification normally disappear in the female knee about the age of five in the male about ten. This alone, apart from the influence of external or internal trauma probably explains the rarity of the Juvenile variety in the female.
14 In the knee the anatomical form and function of the joint determines the frequency of occurrence
15 The endogenous mechanical factor in the Adult variety in particular is contact between medial eminence of tibial spine and classical site
16 In Freiberg's infraction early operative measures based on a clinical diagnosis offered the opportunity to study a juvenile osteochondritis before radiological changes had occurred
17 The pathological anatomy both macroscopic and microscopic is the same as the local lesion in osteochondritis dissecans of the knee
18 That the fracture in Freiberg's infraction (or in osteochondritis dissecans) occurs without haemorrhage determines the relationship to ischaemia and the order of events
19 The basic pathology affects bone not cartilage.
20 The means pathological and mechanical whereby a fracture in ischaemic bone can underly normal cartilage is detailed
21 The circumstances determining the site of the final isthmus of cartilage, and the sequence of events terminating in the incident when it gives-way *and the loose body is cast into the joint, are described*
22. The absence of ischaemia in the bone forming the base of the crater distinguishes the lesion of the single incident fracture from osteochondritis dissecans

OSTEOCHONDRITIS DISSECANS OF THE VARIOUS JOINTS, AND LIKE CONDITIONS, COMPARED AND CONTRASTED

Etiological Factor	*Degree*		
Constitutional dysostotic	■	■■	■■■
Endogenous mechanical	■	■■	■■■
Exogenous mechanical		— —	- -

If for example the four conditions of similar radiological appearance recorded on page 3 are measured against the table of etiological factors, the list would appear

1 ANOMALY OF OSSIFICATION ■■■
2 JUVENILE OSTEOCHONDRITIS DISSECANS ■■■
3 ADULT OSTEOCHONDRITIS DISSECANS ■■■
4 TANGENTIAL OSTEOCHONDRAL FRACTURE

If then the list of the sites of the lesions in the various joints is subjected to the same yardstick it would read

KNEE

1 Classical site infra lateral aspect medial femoral condyle ■■■ or ■■■
2 Infra-central aspect medial femoral condyle ■■■ or ■■■
3 Infra-central aspect lateral femoral condyle ■■■ or ■■■
4 Antero-lateral aspect lateral femoral condyle ■ or

METATARSO-PHALANGEAL

Metatarsal head ■ or ■■

ELBOW

Capitellum ■■■ or ■■
Head of Radius ■■■ or ■■

ANKLE

Supra medial aspect talus ■■■ or ■■■
Supra lateral aspect talus ■■■ or ■■■

HIP

Superior aspect head of femur ■■■

PART II

CLINICAL FEATURES TREATMENT

CHAPTER 9

KNEE

CLINICAL FEATURES

OSTEOCHONDRITIS dissecans like most conditions of the knee joint of traumatic origin in youth, is most common in the male The symptoms are indefinite The complaint is of discomfort, rather than of pain. It is made worse by exercise There is an ache in the joint at rest. There are recurrent effusions often described as occasional swelling, brought on by exercise but which subside rapidly with rest. Instability in the form of giving way or the feeling of giving-way is a common and important feature Locking is the most definite and the most dramatic of the symptoms presented.

Swelling.—It is unlikely that the recurrent swelling is related, other than indirectly to the lesion It is the giving way incidents which inflict trauma on the synovial membrane and result in the transient effusions.

Giving way—Instability under stress is perhaps the most characteristic and interesting of the symptoms and yet one of the most confusing in that it suggests a meniscus lesion It is clearly due to the fact that a weight-bearing area of articular cartilage is unsupported by bone It may occur even when the lesion is in the classical situation and apparently non weight-bearing This may be due to contact by the tibial spine with the area on the lateral aspect of the femoral condyle which is now loose.

Locking is due to (1) **Torn Meniscus** It is known that in a proportion of cases a tear of the meniscus is the cause of the injury to the femoral condyle. In these circumstances symptoms of locking which clearly implicate one or other meniscus do not eliminate the possibility of a second lesion in the form of osteochondritis dissecans A radiograph is necessary in every meniscus lesion no matter how obvious the clinical diagnosis. (2) **Partial Mobility of the Fragment.** At operation the fragment is often noted to be free within the defect in the condyle except for a pedicle of posterior cruciate ligament. This pedicle permits the fragment to hinge forwards (Figs. 4, 39

and 4, 40) or rotate with the cavity (Figs. 4, 41 to 4, 44) In such circumstances it can be caught between femoral and tibial condyles and produce locking. Unless this possibility is recognised the radiograph showing the fragment within the cavity may not appear to explain the incidents (3) **Completely Free Loose Body** The locking is positive but usually of a momentary nature and after a few incidents patients are frequently aware of the cause It should be recognised that there are circumstances in which a loose body can produce a permanent block to extension The situation has been encountered on so many occasions that it is worthy of record and particularly as it stimulates the block to full extension produced by a complete longitudinal tear of the medial meniscus which has become permanently displaced into the centre of the joint. The loose body about the size and shape of an almond is driven between the anterior horn of the medial meniscus and the tibial table It raises the level of the meniscus and thus constitutes a block to extension. The bony element of the loose body is small and situated close to the bone of the tibial table, passes unnoticed in the radiograph

Examination.—In the early stages examination may reveal no constant *sign except wasting of the quadriceps which is always present but in varying* degree, and merely indicates that there is something wrong with the joint" If the patient is young the examiner may realise that he is not dealing with a straightforward meniscus injury and think of the possibility of osteochondritis dissecans.

Careful deep palpation of the femoral condyle with the knee in rather more than right-angled flexion but not full flexion may reveal local tenderness over the lesion in the articular cartilage If the fragment has already separated into the joint the defect in the condyle may sometimes be palpable if it is large and situated in an accessible area

The diagnosis usually presents no difficulty if the fragment has separated. The majority of patients are aware of the existence of a freely mobile loose body and will frequently indicate the site of one which is adherent to synovial membrane.

RADIOGRAPHY

It will be admitted particularly by the experienced that osteochondritis dissecans of the knee at the stage before the fragment has separated is a radiological diagnosis. It is not like Freiberg's infraction where a virtually positive diagnosis can and should be made on clinical grounds In the knee the possibility may be considered the surgeon is usually gratified if his suspicions are confirmed But unfortunately it is not just as simple as that The

presence of apparently normal radiographs does not rule out the possibility of osteochondritis dissecans

1 **The loose fragment may be composed of articular cartilage alone.** This is rare in youth and relatively unimportant even in adult life The fragment usually separates through the superficial layers of the bone.

2 **The space between the femoral condyle and the separating bone fragment may be so narrow that it does not show in the film.** Langton (1942) has pointed out that such circumstances occur and lead to errors of diagnosis in fractures of the carpal scaphoid Lachmann (1938) has shown experimentally that a space of at least one millimetre between the fragments of a fracture in the knee joint is necessary before the line of separation can be identified radiologically

3 **With the exception of gross displacement, even one millimetre of separation will not show unless the rays are tangential to the femoral condyle at the site of the lesion.** A considerable number of tangential views of the femoral condyle are therefore necessary in a suspected case before the possibility of a radiological abnormality can be eliminated The intercondylar or tunnel projections are particularly helpful at all stages of the disease. The most dramatic picture occurs when the rays are parallel to the line of cleavage.

The question naturally arises what interval of time must elapse between the original injury and the presence of recognisable radiological changes? Alternatively how long does absorption at the fracture line take to attain a thickness of one millimetre? The answer to these questions was not revealed in this series Nor have we any idea of the interval between the fracture and *the onset of symptoms It may not occur until the fragment is loose* In many cases there are virtually no symptoms until the locking of a loose body and yet it is obvious that the condition has existed for many years. It must therefore be admitted that in the present stage of the development of radiographic technique the diagnosis of many suspected cases must depend on clinical and radiological examinations repeated at monthly intervals. It should therefore be remembered when the first positive signs of the lesion are revealed and a decision must be made about treatment, that, like the comparable lesion in the metatarsal head the pathological anatomy is much further advanced than the early changes in the radiograph would suggest.

Tomography—*It is clear that simple radiographic technique as applied* to fractures is of limited value in osteochondritis dissecans. The conventional antero-posterior and lateral views on which diagnosis is normally based are no more than a summation of the details in a bone of considerable dimensions,

gross lesions only are depicted Nevertheless osteochondritis dissecans remains a diagnosis based on radiological examination

It was recognised early in the series that tomography as a technique which visualised the object examined layer by layer held considerable attractions in localisation prior to operation It was applied but only when the possibility of difficulty in localisation arose, in relation to the talus where the operative access is limited. It was seldom used in the knee joint if only for the reason that the multiple exposures necessary seemed an unjustifiable addition to the many normally employed in both diagnosis and treatment.

The advent of multiple-layer single-exposure tomography has literally changed the picture and removed the possible hazard inherent in the original techniques. This latest method was employed extensively in the localisation of lesions in the knee joint in the later cases of the series and to follow the effects of operation. It is clear however that the potentialities of the new technique in diagnosis, and particularly in combination with contrast media have yet to be exploited.

DIFFERENTIAL DIAGNOSIS

1 **Common internal derangements particularly lesions of the menisci** — Lesions of the menisci are relatively uncommon before the age of 15 Internal derangement before that age carries with it the suspicion of osteochondritis dissecans It is after that age particularly in young adults that mistakes arise and especially in the early stages when there are no positive findings in the radiograph It is customary to take straight antero-posterior and lateral radiographs of every internal derangement relative to a meniscus no matter how apparently obvious the diagnosis The combination of osteochondritis dissecans with a meniscus lesion is by no means rare

But radiographs are not always scrutinised as carefully as they might be The author recalls in the year 1943 raising his eyes from the knee joint of a young soldier from whom a normal medial meniscus had just been excised only to see in the radiograph on the viewing box the unmistakable signs of an early osteochondritis dissecans Closer examination of the knee then revealed the site of the lesion on the medial femoral condyle Failing to examine radiographs is no better than taking no radiographs at all In a recent example referred since the conservative surgery of osteochondritis dissecans has been shown to be effective, the patient had suffered the removal of a normal medial meniscus It was only when he failed to recover that the first radiographic examination was made and revealed a well-defined lesion capable of operative repair

In respect of radiographs too it is important, particularly in young people in the, say 10-18 age group to get further plates if any delay has occurred between the original clinical examination and admission to hospital.

Example To illustrate the point is quoted the case of B A., male, aged 12 (K124 Table III) who sustained two locking incidents six months before admission to hospital At the time of the original incident a paediatric surgeon made the diagnosis of a torn congenital discoid lateral meniscus. When he was seen five months later the pattern of symptoms and signs did not appear to implicate the lateral meniscus the loud click seemed to originate on the medial side of the joint.

When he was admitted to hospital, one month later further radiographic examination demonstrated a possible lesion in the classical situation. It was decided therefore to open the joint on the medial side

At operation there was a large lesion at the classical site measuring at least 2″×1″ The loose body consisting largely of articular cartilage and without more than a granular surface of bone, was displaced into the intercondylar notch. The radiographs did not reveal the fact that this large loose body had separated.

If radiographs had not been taken on this patient's admission to hospital six months after the original examination the possibility of an osteochondritis dissecans lesion might not have been suspected and no preparations made for repair

2. **Recurrent subluxation of the patella.**—Reference has been made in the course of development of theories regarding etiology (page 53) to the association which may exist between recurrent subluxation of the patella and a lesion at the classical site From the clinical viewpoint, however where there are symptoms of a loose body in the knee and the source is not immediately evident from the usual antero-posterior and lateral radiographs, the possibility of an osteochondral fracture of the patella should be considered and a tangential view secured It is not unknown for the loose body from an osteochondral fracture to be the first indication of the true nature of the diagnosis It has been recorded (Smillie 1951) that recurrent subluxation of the patella is a diagnosis which is commonly missed Symptoms of a loose body in the female subject in particular should call attention to the possibility of recurrent subluxation of the patella and the related osteochondral fracture as the source of the free fragment.

3 **Anomalies of ossification.**—The literature of recent years has recognised the possible radiological confusion between variations of ossification and osteochondritis dissecans (Caffey 1956 Roche and Sunderland 1959) Constant reference to this aspect of the subject throughout the text makes it clear that the greatest difficulty of diagnosis lies in differentiating certain anomalies of ossification which might disappear spontaneously from Juvenile osteochondritis dissecans. The problem arises in particular at or about the

age of 10 and in brief it can be said that anomalies persisting after that age should be suspect as possible precursors of Juvenile osteochondritis dissecans and accordingly kept under close clinical and radiological observation

4 **Tuberculosis**—This condition is one of diminishing importance in many countries but it must be remembered as a possibility in diagnosis in the child

TREATMENT

It has been known for more than two decades that what was thought to be osteochondritis dissecans of the knee joint will heal in children with rest or even spontaneously (Kappis 1920 Decker 1938 Wiberg 1941 Strange 1944 Smillie 1946 Van Demark 1952 Green and Banks 1953 *etc*) It was known also but for a lesser period, that this capacity is lost with maturity and might not extend beyond adolescence (Wiberg 1943) Treatment thereafter was based on the acceptance of what was considered to be inevitable the fragment eventually separates into the joint as a loose body leaving a crater in the articular surface which depending on site and size will interfere to a greater or lesser extent with the future function of the joint

An explanation of these phenomena has been offered cases which heal spontaneously are examples of anomalies of ossification. It is probable that established Juvenile or Adult osteochondritis dissecans does not heal

This section records the experience of an attempt to treat osteochondritis dissecans of the knee joint on a more idealistic level. It confirms the possibility of healing in children of anomalies of ossification the precursor stage, by conservative means It proposes to show that timely operative intervention can prevent separation of fragments and result in healing. Finally it proposes to show that timely operative intervention can restore the anatomy of the part and result in healing even after separation of fragments has occurred

COMPARISON WITH TREATMENT OF FRACTURES

It has been stated that it is characteristic of osteochondritis dissecans of the knee that the many stages in the pathological anatomy which exist, before the last isthmus of cartilage or ligament gives-way are represented by not dissimilar radiological appearances But whether the overlying articular cartilage is intact as it may be, or indented or soft and raised above the surrounding surface or partially separated the feature common to all is an area of horizontal cleavage in the superficial layers of the underlying bone The horizontal cleavage represents the fracture line True

osteochondritis dissecans however differs from other fractures in that it occurs in dead bone and is never seen in the recent state. Unfortunately the symptoms, at all stages save the dramatic locking of the final loose body are ill-defined and transient years may pass before the patient gives the opportunity for diagnosis. Treatment is thus determined by the stage at which the fracture is presented. Each demands different methods comparable with those in current use whereby delayed union is treated by rest, supplemented by some method of improving local blood supply established non-union by freshening of the bone ends, possible internal fixation to maintain alignment, and rest.

SPONTANEOUS HEALING

There are numerous references in the literature to spontaneous healing with a variety of interpretations of the meaning of spontaneous. Treatment in these spontaneous cases has varied from limitation of activity (Wiberg 1941) to plaster immobilisation (Van Demark 1952) or even complete bed rest for six months (Decker 1938) While it is recognised that true spontaneous healing could occur and indeed is in keeping with the fracture analogy propounded, it is probable that many of the cases recorded were not established Juvenile osteochondritis dissecans. Examination of the literature shows, in so far as the interpretation of reproductions of radiographs will permit, that many of the cases claimed to have healed spontaneously or by immobilisation only were in fact examples of anomalies of ossification, a proportion of which would have disappeared in any event with nothing more than the passage of time

It is probable in the light of increased experience, that four cases, previously recorded as having healed by immobilisation alone (Smillie 1957) but no longer included, were of this variety and might have healed anyway But even if we accept the possibility of true spontaneous healing in established osteochondritis dissecans it is probably unwise to take no more action than to keep a child under observation for the two years (Wiberg 1943) to seven years (Green and Banks 1953) required when methods of therapy exist from which a return to radiological and clinical normality can be anticipated in a relatively short time Further if it is accepted that the condition heals spontaneously or by immobilisation alone, it must also be accepted that a point may be reached in the pathological anatomy when the process is irreversible Observation may be dangerous but the younger the child the greater the tendency to return to normal and the less will be the risk

True spontaneous healing of established osteochondritis dissecans was not observed in this series

BACKGROUND TO REPARATIVE MEASURES

Drilling.—At certain stages in development, before the loose body is discharged into the joint, the lesion has all the radiological appearances of an ununited fracture with opposed surfaces of sclerotic bone and an intervening clear space In the ordinary ununited fracture the radiological clear space is dense fibrous tissue. In osteochondritis it is an actual space and yet the over-lying articular cartilage may be intact or merely depressed as a result of loss of support from absorption of bone This is the type of case to which an operation to produce a fresh blood supply to both sides of the fracture but with the minimum interference with the overlying articular cartilage, is particularly applicable

The multiple drilling of opposed sclerotic fragments in an ununited fracture in order to introduce a new blood supply has been practised since before the First World War (Wildey 1914) The method has gradually fallen into disfavour in the face of newer and much more certain methods of promoting union. There are however special circumstances in osteochondritis dissecans which make the method applicable in particular the absence of a barrier of dense fibrous tissue between the fragments. The penetration from without inwards of the small fragment through the sclerotic zone of the condyle to a source of blood supply can be expected to result in the filling up of the entire space between the fragments with blood clot, which would be transformed into granulation tissue by capillaries growing out from the host and thus form a source of blood supply for the dead bone

Drilling and internal fixation.—The follow-up of cases from which a massive loose body consisting of a high proportion of the weight-bearing surface of the medial femoral condyle, has been removed provided the stimulus to attempt to repair the defect. The result of operation even had it failed could not have been worse than the disaster which occurs in any event. But there was no reason to anticipate failure. The articular cartilage of a loose body is alive and proliferating the bony element no more dead than before discharge into the joint and it was known that before separation it could be revascularised from a suitably prepared bed.

The original case in which the loose body was retained and healing occurred has been recorded previously (Smillie 1951) The two paragraphs and the radiographs to which they refer are reproduced in order that the background to the more constructive attitude to operative treatment may be complete

"In this series the case of an adolescent male was encountered in which marked sclerosis of the bone lining the cavity containing the fragment influenced

FIG. 9 1



FIG. 9 2





FIG 9 3



FIG. 9 4

Original case in which a loose body was returned to a prepared crater (Figs. 9, 1 and 9) Four months later radiological healing had occurred (Figs. 9 3 and 9 4).

the decision against conservative treatment (Figs. 9, 1 and 9, 2) At operation instead of removing the fragment, as is the usual practice, the fibrous tissue lining the crater was excised and the sclerotic base vascularised by multiple fine drill holes the apposing surface of the fragment was subjected to the same process. The fragment was then replaced and the limb immobilised in a plaster cast At the end of four months radiological healing had occurred (Figs 9, 3 and 9, 4) three months later full function had been restored in the joint.





FIG 9 5 FIG. 9 6

The fragment consists of a very large proportion of the total weight bearing area of the medial condyle *The patient refused treatment when the opportunity for conservative surgery was present* in 1948 The loose body was removed (elsewhere) in 1951 He was last seen in 1959 with gross osteoarthritis and will soon be pleased to accept arthrodesis

"The success of this case prompts the suggestion that restoration of the anatomy might be attempted in certain selected cases in adults. In an early case, could the cavity following the excision of fibrous tissue and sclerotic bone, be filled with fresh cancellous tissue, scooped from the depth of the condyle to form a vascular bed for the fragment? Could internal fixation by means of a screw fixed beneath the articular cartilage be used? Could the result of such measures, applied to the case illustrated in Figs. 9, 5 and 9 6 possibly be worse than excision of a fragment which to all intents and purposes consists of the entire weight bearing surface of the condyle?"

In the first case in which internal fixation was used (A. L., female, aged 15 K44 Table III) the loose body which was of massive type had been free in the joint for six weeks and required to be pared down to fit the crater Some



FIG. 9. 7



FIG. 9. 8



FIG. 9. 9



FIG. 9. 10

FIG. 9. 7 and 9. 8 The massive loose body which consisted of a large proportion of the weight-bearing surface of the medial femoral condyle, had been free for at least six weeks (R. M., male, aged 19 K70, Table III) FIG. 9. 9 The crater FIG. 9. 10. Articular cartilage at exploration fifteen weeks later Replacement is imperfect but the screw has provoked no reaction.

form of fixation was essential and effected by means of a single vitallium screw Sixteen weeks later when the density of the fragment approached that of surrounding bone the joint was re-opened to remove the screw At operation it was seen that healing was complete but with some irregularity of contour due to depression of one extremity below the general surface The screw had provoked no reaction.

In the second case of the same massive type (R M male, aged 19 K70 Table III) greater difficulties of accurate replacement were encountered due to tissue loss. A screw was again used for fixation. At re-exploration the lesion had healed but the fit had been less accurate than formerly and the impression gained that some absorption of articular cartilage had occurred adjacent to the small raw area of bone which had been left exposed The screw had provoked no detectable reaction (Figs 9, 7 to 9, 13)

It was at this stage that it was realised that a screw while possessing certain advantages, was not the ideal method of fixation It is difficult to introduce and indeed the lesion may be located in such a position that insertion is impossible. Further once inserted no adjustment of alignment is possible Consequently in the third case in which two large fragments were present small pins not dissimilar to the common commercial pins used in cloth but constructed of fine stainless steel Kirschner wire were used. Although they served the purpose, they were unsatisfactory in that a tendency to bend made them difficult to insert and when removed they were found to be eroded immediately distal to the heads presumably as a result of the heat used in manufacture

In the fourth and all subsequent cases, stainless steel nails of one or one and a quarter inches long (2 5 cm or 3 175 cm.) and of one-sixteenth inch (1 5 mm.) diameter without heads but with a groove at the extreme proximal end to facilitate removal were used (Fig. 9, 24)

Other methods of internal fixation.—The appearance of destruction of articular cartilage adjacent to an abnormal source of blood supply at an early exploration for the removal of a screw determined the decision not to use bone grafts or other reaction provoking material as a means of internal fixation Neither the early Vitallium screws nor the present stainless steel nails have provoked detectable reaction But other methods have been used or are in use. Osborne (1955) has used a peg bone graft Bado (1956) screw or nail Harris (1956) nails of beef bone Nova Monteiro (1957) a stainless steel screw

Articular cartilage is an avascular structure and a blood supply is dele terious to its welfare A bone graft or peg of other absorbable material could be used to secure the bony element of a large loose body But it must be absorbed or incorporated An abnormal blood supply is necessary A situa



FIG. 9 11



FIG. 9 12



FIG. 9 13

FIG. 9 11 Radiograph immediately after replacement of the loose body and fixation with Vitallium screw FIGS. 9 12 and 9 13 Antero-posterior and lateral radiographs nine weeks after removal of screw and twenty-four weeks after internal fixation of the fragment. Radiological healing is complete.

tion has thus been created to the detriment of articular cartilage Only extensive experience can finally establish the advantages of a particular method

Rationale of conservative surgery—If it is accepted that the lesion is of the nature of a fatigue fracture it will be recognised that if the cause is removed and the reparative measure instituted successful recurrence is unlikely Can the same be said for the lesion at the classical site where the high tibial spine or other abnormality remains? In answer to this possible argument against conservative surgery is cited the evidence of other fractures of similar basic pathology in youthful subjects which once healed, do not recur whether it is a March fracture or Freiberg s infraction the bone is strengthened to meet the cause. This is probably true also at the classical site in the knee joint the spine may still impinge and damage the cartilage but the underlying bony support will not refracture

INDICATIONS AND TREATMENT

Immobilisation—It is probable that no treatment other than immobilisa tion would be necessary if the diagnosis could be made early enough but the very features on which the radiological diagnosis is based namely relative density of the bony element of the fragment, or sclerosis of the base of the crater indicate that the condition has existed for some considerable time Sufficient operative experience has been accumulated to appreciate that the possibilities of healing by immobilisation alone are limited

It has been shown in regard to anomalies of ossification that the border line between normal and abnormal is a narrow one from the practical aspect the point where a persistent anomaly becomes Juvenile osteochondritis dissecans impossible to define It is clear however that preventative measures are possible in the Juvenile variety and the condition is so common and so destructive to future joint function that there is every justification for taking prophylactic action when the opportunity arises

There are no absolute indications for immobilisation in anomalies of ossification at the precursor stage guidance only can be given If the condi tion is detected as an incidental finding without symptoms as it so often is, it should merely be kept under clinical and radiological observation It is evident from the observations recorded in Chapter 1 that anomalies persisting after the age of 4 to 5 in girls and 10 to 11 in boys should be regarded with suspicion Consecutive radiographs should be studied with care. Multiple layer single-exposure tomographs are of the utmost value. Alteration of contour of the condyle or of the relation of the so-called accessory centre to the adjacent bone, indicates absorption of supporting cancellous tissue

The single symptom which has been regarded as of most importance in this series has been giving way incidents If giving way incidents are not an absolute indication that a horizontal cleavage lesion has occurred and the articular cartilage no longer supported they are at least the warning that such is likely to occur It has been regarded as an indication for treatment, conservative or operative as the circumstances determine

Treatment by complete rest but particularly by immobilisation in a plaster cast, is of value only and indeed should be pursued only if healing is accomplished in a reasonable time say twelve to sixteen weeks at the most. Prolonged immobilisation and prolonged absence of weight-bearing is harmful to both form and function of the growing joint. If doubt exists, the outcome of the simple drilling operation meticulously performed, is such that the balance is weighed in favour of conservative surgery

The certainty of the drilling operation by comparison with conservative treatment is illustrated by the following case

The patient (P K. female, aged 11 K130 Table III) exhibited a bilateral lesion, originally an anomaly of ossification kept under observation, but whose symptoms proceeded to the stage where giving way incidents became a matter of concern and whose radiographs showed no sign of healing. It was decided, as a matter of experiment, to drill the worse of the two sides and immobilise the joint for twelve weeks. There were circumstances in the home life of the child which demanded that she remain in hospital during treatment it was for this reason that the experiment of treating the less affected side by rest in the form of non weight bearing but without restriction of movement in bed, should be tried. At the end of the twelve weeks there was evidence in the radiographs that the side on which drilling had been performed had healed. The side which was rested was unchanged. A situation was thus created whereby it was necessary to inform the parents that the side which was not subjected to operation had failed to heal and that an operation would be necessary followed by a further period of immobilisation

There are circumstances in which rest, as opposed to direct operative attack may be indicated even in the Adult variety as the following case indicates

The lesion (G T., female, aged 12, K113 Table III), most marked radiologically was located in the middle of the lateral femoral condyle. At operation a torn congenital discoid meniscus was found to underlie the lesion and was excised It was decided, in view of the fact that the cause of the osteo-cartilaginous lesion had been removed and the articular cartilage unfractured, that healing would probably take place with rest The meniscus having been excised the use of a plaster cast was contra indicated A patten-ended caliper was therefore employed to prevent weight bearing but permit mobilising exercises to be maintained At

the end of a total of twelve weeks, when the caliper was discarded the radiological lesion had healed

Operation.—It will be generally accepted that, sooner or later operation in one form or another is necessary in the majority of cases of osteochondritis dissecans of the knee joint. But whether operation should await the separation of loose bodies and remove them anticipate separation and excise the area affected, or attempt the restoration of the articular surface is another matter

The surgeons of the past were content to accept what they thought to be inevitable or were powerless to prevent We do not see our own bad results only those of the previous generation The working man with the osteoarthritis we cannot cure often has a scar on his knee " where a piece of bone was removed thirty years ago " Perhaps his arthritis can be modified or even prevented.

But even those who are content to remove loose bodies concede the desirability of attempting conservative surgery when the lesion is situated on the weight-bearing surface of the femur Lesions in this situation are common Repair is frequently possible It is not suggested that repair can or should be attempted in every case. The long-separated or the comminuted loose body cannot be replaced no matter how desirable. It depends on the size and site of the lesion indeed on so many factors Idealistic measures should not be pursued when it is clear that an idealistic result is unattainable. The attitude to be adopted at fifteen seldom applies at fifty Judgment, more difficult to acquire than technical skill is necessary

INSTRUMENTS

The success of the operative procedures to be described is dependent on the use of non-destructive incisions Access to the classical site on the medial femoral condyle through the small incision normally used for the excision of a meniscus requires special retractors (Smillie 1946) the remaining instruments have been evolved over the past decade.

Retractors.—Three types are employed

1 Simple single-ended instruments of orthodox pattern normally used for meniscectomy and designed to effect the maximum exposure with the minimum trauma to capsule and synovial membrane. Two are required (Fig 9 14*a*)

2 Wide-bladed retractors based on Burrows modification of Nystrom s instruments. The angle in the shaft is 160 that between shaft and blade 60 Three lengths of blade are necessary 1¼ inches (32 mm) 1⅝ inches (41 mm) and 2¼ inches (57 mm) The width of the blades is ¾ inch (18 mm) and the

A

B

C

FIG 9 14



FIG. 9, 15

Instruments

FIG. 9 14 Retraction. (A) Simple meniscectomy retractors to show design of handle and shape of blade (B) wide-bladed retractors showing various lengths of blade (C) retractor for insertion at periphery of joint. FIG. 9 15 Preparation. Gouges and mallet.

thickness of the stainless steel 1/16th inch (1 6 mm) Three one of each length of blade, are required (Fig. 9, 14b)

3 A retractor with a curved blade ⅜ inch (10 mm.) wide which is inserted between collateral ligament and femoral condyle and is useful in the case where it is necessary to gain access to the periphery of the joint. One is required (Fig. 9, 14c)

It is most important in all of them that the edges of the retracting blades are rounded. If they are sharp damage can be inflicted by an assistant who holds the blade at an angle to the structure he is retracting.

Gouges.—These are standard instruments with a blade of a diameter of say 5/32nds inch (3 9 mm) The base of the crater is hard, much harder than anticipated and the use of gouge and hammer has been found the best method of preparation. A gouge too held rather than hammered has been found to be the most satisfactory method of breaking up the deep surface of the bony element of a loose body which has been removed from the joint for preparation (Fig. 9, 15)

Hammer or mallet.—The ordinary light surgical hammer is unsatisfactory in that the head must travel through too large an arc to penetrate the sclerotic bone of the crater with gouge or probe A large headed hammer obstructs the view The instrument eventually evolved drives the gouge probe or nail-gun with its own weight. In certain circumstances the distal end rather than the side can be used It is constructed of ⅞ inch (22 mm) round silver steel bar and incorporates a hand grip It is 7 inches (178 mm) long and weighs 1 lb 1 oz. (482 gm) (Fig. 9, 15)

Modified dental probes.—It is not possible to grip the fragment with forceps, toothed or otherwise Outside the joint the use of the saline moistened gloved forefinger and thumb is recommended Inside, some method of manoeuvring the fragment within the cavity without damage to the articular surface is necessary Modified dental probes have been found to be the most useful instruments for this purpose A single-ended variety with the points at various angles to the shaft is used the double-ended pattern tends to tear the surgeon s gloves. The probes are used in several ways driven into the fractured edge of the articular cartilage or should the necessity arise, into the articular surface direct where the single puncture inflicts the minimum possible trauma finally the different angles allow areas of horizontal cleavage at various angles to intact cartilage to be located through the small stab wound used for drilling.

Straight probes with points of various thickness constructed also from dental probes are used to perforate the base of the crater *In this most*

important part of the replacement operation the small hand grips are an advantage rather than a disadvantage Reference has already been made to the density of the bone The perforating instrument may require to be driven in with the mallet If a fine-pointed instrument is fitted with a large handgrip too much power or leverage can be exerted and the point broken deep within cancellous tissue (Fig. 9, 16)

Nails.—The nails are one or one and a quarter inches long (25·1 or 28 2 mm.) and of 1/16th inch (1 5 mm) stainless steel They have no heads but a deep groove is cut at the proximal end to facilitate extraction. The groove is situated as close as is technically possible to the end in order that the nail can be driven virtually flush with the articular surface and yet the means exist for removal Smaller nails ⅝ ¾ and ⅞ inch (16 19 and 22 mm) long and of similar construction are used for the repair of recent articular fractures in other joints.

Nail gun.—The nail is inserted with a cannulated instrument of an internal diameter slightly greater than the nail It has a smooth mushroom-shaped end for contact with the articular cartilage which permits the nail to be driven at a slight angle if necessary but without damage to the joint surface Protruding into the cannula immediately above the mushroomed end is a spring which holds the nail in position This adds to the complication and also to the cost, but lessens the possibility of dropping the nail or disaster of disasters, the fragment mounted on the nail The nail is driven along the cannula with the trochar which also acts as a depth gauge That part which projects is the length of nail to be driven home (Fig. 9, 17)

Nail punch.—When the nail has been inserted as far as the trochar will permit a small part still projects from the articular surface. The final driving home is accomplished with a punch of similar shape and size to the bone gun (Fig. 9, 17) In addition two small pin punches of different sizes are included for use in positions inaccessible to the larger instrument.

Instruments for extracting nails.—The simplest method of extraction is to insert the point of the fine gouge described into the groove in the neck and lever the nail out. Other methods include the use of a miniature tack-lifter the Vee end of which is designed to fit the groove in the neck (Fig. 9, 18*a*) or a pair of fine-pointed forceps designed to grip the groove (Fig. 9, 18*b*) Finally in the list is included a small trephine for use if the end of the nail is below the level of the articular surface This instrument has been constructed in the form of a punch so that it can be gently driven into the articular cartilage surrounding the head and then rotated to remove a small circle of articular cartilage and thus provide access to the groove (Fig 9, 18*c*)

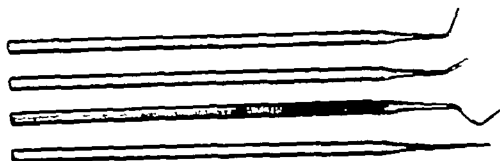


FIG. 9 16

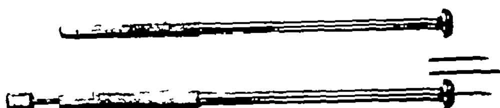


FIG. 9 17

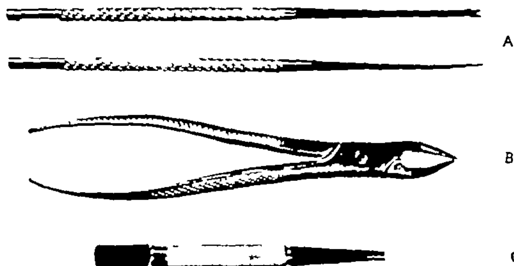


FIG. 9 18

Instruments

FIG. 9 16. Penetration Modified dental probes with straight and angled points. FIG. 9 17 Fixation Nail gun, punch and nails. The nails illustrated are one inch and one and a quarter inches long. FIG. 9 18 Extraction. (A) Miniture tack lifter (B) forceps, (C) trephine

TECHNIQUE OF OPERATION

The operation is performed under tourniquet with the knee flexed over the end of the table as for excision of a meniscus. The incision is that used for the removal of the medial or lateral meniscus depending on the condyle involved (Fig 9, 19) The non-destructive nature of the approach is stressed.



FIG. 9 19
Incision used for approach to classical site The exposure must be innocent in terms of permanent impairment of function.

Parapatellar incisions which lay the joint widely open are unnecessary and undesirable The procedure is justified only if the exposure used is innocent in terms of permanent impairment of function Access to the classical site on the medial condyle varies with sex, conformation and size of fat pad. The use of the meniscus operation retractors and the three sizes of long-bladed knee-joint retractors (Smillie 1946) is recommended (Fig. 9, 14) Division of the anterior and antero-central attachments of either meniscus should be avoided. Such measures improve the access to the condyle but experience has shown that fixation of the anterior horn is thereafter inadequate

The next step is determined by the nature of the lesion

1 **The loose body is quite free, as in the massive variety, or lying in the intercondylar notch attached by a few strands of posterior cruciate ligament, as frequently occurs at the classical situation, or is virtually free, attached only**



Fig. 9 20



Fig 9 21



Fig. 9 _



Fig. 9 23

Figs. 9 20 and 9 21 Radiographs to show site and size of lesion. Fig. 9 2_ Crater and adjacent loose body Fig. 9 23 Appearance after drilling, replacement and introduction of nail. The loose body is slightly depressed in relation to the surroundings.

by a narrow isthmus of articular cartilage In these circumstances the crater is prepared by excising any fibrous tissue that may line the margins and by drilling the base In the latter measure the sclerotic bone will be found to be much harder than expected and much time will be saved by the use of the fine-pointed gouge and mallet illustrated (Fig. 9, 15) If the loose body retains a ligamentus attachment this may be preserved and any drilling of the bony element carried out within the joint using a dental probe for fixation and the modified dental probe for drilling. If however the bony element is large and dense, preparation of the fragment may best be carried out outside the joint. If the loose body is free the facility with which it can be replaced is not unnaturally related to the interval between displacement and operation Preparation of the proliferated margins must take place outside the joint. If the fragment sinks too deeply into the crater the level can be adjusted by digging bone outwards from the base or supplementing with autogenous cancellous tissue. The direction in which the nail is inserted is determined to a large extent by the position of the lesion and by the access available It cannot always be driven at right angles to the surface A second nail may be necessary if the fragment is large or adjustment of the levels difficult. In general nails shorter than one inch (2 5 cm) should not be used If the base of the crater has been thoroughly prepared the nail must be driven some distance into the femur before gaining a hold It may thus appear long in comparison with the size of the fragment it secures (Fig 9, 24)

Preparation of the fragment outside the joint —When the fragment is free or attached only by a stalk of posterior cruciate ligament or other soft tissue, it is best removed from the joint in order to permit the dense bony element to be drilled or otherwise prepared for revascularisation There are certain attractions in retaining the isthmus of soft tissue as it enables the loose body to be returned to the crater in a predetermined position but experience has shown that the breaking up of a dense bony mass is so important that direct access, only possible outside the joint, is essential to ensure the maximum opportunity for revascularisation Further if it is true that the attachment of the posterior cruciate ligament to the fragment is at least one of the factors responsible for the failure of healing, then it is not unreasonable that the fragment be freed completely Thus detachment may not be as radical a move as might first appear

In removing the fragment from the joint it should be noted that synovial fluid is slippy and articular cartilage the slippiest substance known (Charnley 1955) In these circumstances the greatest care is necessary to prevent a disaster either in transit or during preparation To prepare the bone, the fragment is placed articular surface downward on a smooth towel moistened



FIG. 9 24



FIG. 9 25



FIG. 9 26

FIG. 9 24 Post-operative radiograph which shows groove in nail to facilitate extraction. FIGS 9 25 and 9 26 Antero-posterior and lateral views six weeks after removal of the nail. Radiographic healing is complete but a slight depression can be seen in the contour of the condyle

with saline It is held against the towel with forefinger and thumb and the surface broken up with the same fine gouge used to prepare the base of the crater It is then returned to the crater and aligned with the surrounding articular cartilage A point is selected suitable for the driving of the nail and a small puncture made in the articular cartilage with the straight probe. The fragment is then removed from the joint once again and the probe driven on through the articular cartilage and bone in the predetermined direction. The nail entered in the nail gun is now gently driven through the articular cartilage and bone until the point appears on the deep surface The fragment, with the nail and nail gun attached, is now returned to the crater where it will be found that the nail gun enables the position to be controlled without difficulty When the cartilaginous surfaces are adjusted to the required level the nail is driven home (Figs 9, 20 to 9, 26)

2. **The loose body has not separated but is outlined by fibrous tissue protruding through a recent fissure, or by fibrous tissue lining a well established gap, the body is attached laterally by tags of posterior cruciate ligament and medially by an isthmus of intact articular cartilage.** In these circumstances a decision must be made whether to leave the potential loose body undisturbed and treat by drilling alone or divide the soft tissue or cartilage and hinge the loose body in one or other direction in order to gain access to all aspects of the lesion The choice will depend on local conditions but the lesion is usually more extensive and the pathological anatomy further advanced than first impressions indicate Radical measures are more certain of success even if they entail the use of internal fixation (Figs 9, 27 to 9, 30)

3 **No lesion is visible on the articular cartilage, or the site indicated by a raised area surrounded by a shallow gutter, or by a shallow groove, depression or flat area, but in any event the articular cartilage is unfractured.** This is the type of case to which simple drilling can be applied The first step is accurate localisation of the lesion To this end inspection, related to the radiographic findings may be all that is necessary Sometimes although the cartilage is intact, a search in the intercondylar notch above the rolled edge of the articular surface will reveal tags of fibrous tissue protruding from a fissure which leads into the horizontal cleavage. The actual fissure cannot be seen but the point of a button hook retractor can be inserted into it. If no indication of the site of the lesion exists, or if the indications are indefinite, radiographs with markers of the straight pointed probes or of Kirschner wire in position should be secured to avoid the possibility of error (Fig 9, 31)

A point is selected at about the centre of the bony element and a small stab wound inflicted on the articular cartilage through which the drilling is performed Originally a fine diamond-pointed drill was used but experience



FIG 9 27



FIG 9 28



FIG. 9 29



FIG. 9 30

Conservative Surgery in Osteochondritis Dissecans of Knee: Stages of Operation

(A D male aged 20 case K146, Table III Bilateral osteochondritis dissecans of patella and at classical site medial femoral condyle Left knee) FIG 9 27 Large loose fragment at classical site depressed below surface of surrounding articular cartilage FIG. 9 28 Fragment lying immediately outside crater FIG. 9 29 Crater has been prepared and fragment replaced at level of surrounding surface and secured with nail Note blood from prepared cancellous tissue in fissure surrounding replaced fragment. FIG 9 30 Site at re-exploration three months later immediately prior to extraction of nail. Note degree of healing site indicated by shallow groove no reaction at nail head.

has shown that after two or three entries the drill tends to follow a previous track The sclerotic bone is best broken up by feel. Perforation of the area in every possible direction consistent with the use of a small common point of entry is accomplished most easily with a fine sharp-pointed instrument such as

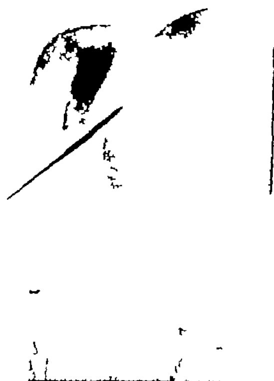


FIG 9 31
If doubt exists about the exact position of the lesion, radiographs with a marker of Kirschner wire in position are taken to avoid the possibility of error

a straightened dental probe driven directly inwards by hand (Figs. 9, 32 to 9, 36)

It will be appreciated that the multiple penetration of the bony element of a potential loose body close to the point of entry in the articular cartilage is impossible Multiple penetration of the base of the potential crater at a distance from the point of entry is a different matter Circumstances may therefore exist in which the apparently radical measure of raising a flap of articular cartilage in order to gain access to the opposing surfaces of the fracture may be justifiable When this has been done it has been the practice to make the incision in the articular cartilage through abnormal tissue as for example, in the depth of a groove. The flap is then gently retracted on a hinge of normal



FIG. 9 3



FIG. 9 33

FIGS. 9 3 and 9 33 Extensive radiological lesion. FIG. 9 34 Site of the lesion is indicated by a raised area and adjacent depressed zone of darker colour Articular cartilage is unbroken.



FIG 9 34

cartilage. At the end of the procedure the flap is returned and a decision made as to whether or not internal fixation is necessary

Approach from the side—In an operation which aims at perfection it is undesirable to inflict even minor injury to the articular cartilage if it can be avoided. In the drilling of sclerotic bone beneath an unbroken surface



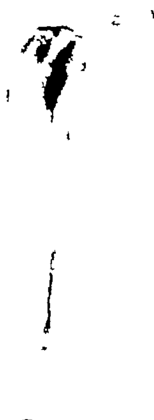


FIG. 9 35 FIG 9 36

Antero-posterior and lateral views twenty weeks later Radiographic healing is complete.

therefore the question of approaching the site from the side rather than from below should always be considered. This arises in particular in a child with a narrow femoral condyle and the more experience which was accumulated the more attractive became such an approach in the Juvenile type.

When this method is adopted, a window one quarter inch square, is cut on the rolled articular margin on the medial aspect of the medial condyle, or the lateral aspect of the lateral condyle exactly opposite to the lesion as indicated by a flattening of the surface corresponding to the known site in the radiograph To gain access some cancellous tissue is removed immediately deep to the window and preserved. The sclerotic bone of the lesion is then broken up with the point of a fine gouge entered through the window In some

cases when the gouge touches the hard bony nucleus the sensation is transmitted to both surgeon and assistant holding the retractors At the termination of operation the cancellous tissue is replaced (Figs 9, 37 and 9, 38)





FIG. 9 37 FIG 9 38

Drilling operation, approach from the side (Fig. 9 37) Dental probe entered from medial aspect of medial femoral condyle Point of second probe entered from below in order that the radiograph (Fig. 9 38) can demonstrate that the lesion has been located

Associated meniscus lesion —Reference has been made to the association of a meniscus tear with a dissecans lesion frequently located in the centre of either condyle rather than at the so-called classical site. In such circumstances the meniscus must be removed in addition to whatever treatment is indicated in the osteo-cartilaginous lesion It is clearly undesirable to immobilise a knee joint following meniscectomy Thus the treatment of these associated conditions is at variance. On opening a joint and finding a torn meniscus the temptation to remove it should be resisted until a decision is made regarding the repair of the articular surface If the procedure involves the use of internal fixation a second operation will be necessary to remove the nail and excision of the meniscus can be deferred until that time This enables the normal after treatment of the meniscus operation to be pursued If the condylar defect demands only relief of weight-bearing or drilling without internal fixation the torn meniscus may be excised in the knowledge that immobilisation in plaster will not be required

On the one occasion when it was considered desirable to follow an extensive drilling procedure by a prolonged period of fixation in plaster the centrally displaced portion only of a complete longitudinal (bucket-handle)

tear was excised in order to avoid interference with the peripheral synovial attachment and possible subsequent difficulty in mobilisation of the joint.

APPLICATION OF METHODS TO RECENT FRACTURES OF THE ARTICULAR SURFACE

If the methods described are successful in the treatment of osteochondritis dissecans they can be applied with even greater success in recent fractures involving an articular surface. A result indistinguishable from normal has been obtained in a fracture of the lateral condyle of the femur in which the greater part of the articular surface was loose in the joint. Similar methods, and the same means of internal fixation have been applied to avulsion of the inferior tibio-fibular ligament with a fragment of bone from the articular surface of the tibia, fracture of the lateral condyle of the humerus, Bennett's fracture dislocation of the thumb etc The technique is similar to that described but entails no more preparation of fragment or crater than the removal of blood clot and fragments of bone to permit absolute accuracy of replacement. If the nail or nails can be inserted from a non-articular site they do not require to be removed.

AFTER TREATMENT

The factor which has influenced after treatment has been the need to secure at least right-angled flexion to gain access to the nail. Initially the joint is treated as if a meniscus had been removed but at the end of the second week instead of permitting a gradual return to weight-bearing mobilisation proceeds until it is clear that full flexion is attainable Thereafter a plaster cast, excluding the foot is applied in extension and the patient permitted to get up using a patten and crutches Joints are designed for movement and deterioration occurs with rest Nutrition of articular cartilage is more efficient if function is preserved In children an alternative measure, when local considerations suggested that rigid immobilisation is unnecessary and only weight bearing forbidden has been the use of a patten-ended caliper In certain selected adults a patten and crutches without the use of plaster on the affected side has been the method of choice

Quadriceps exercises in the form of muscle setting together with straight leg and loaded straight-leg raising are practised at hourly intervals from the fourth day At the end of ten to sixteen weeks depending on the estimate of healing time the plaster is removed, radiographs are taken and remobilising exercises are begun.

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In general no difficulty has been encountered in regaining full flexion. It is presumed that this is due to the mobilisation practised prior to the application of plaster but whether this mobilisation is absolutely necessary has not been established with certainty It will be accepted that if the meniscus had been removed it would be undesirable to put the joint at rest in plaster for a matter of three months. Reference has been made to the technique to be employed if the meniscus is torn It may be, in view of the fact that apart from the anterior incision there is no interference with the soft tissues surrounding the joint that there is little danger of stiffness following operation The anterior scar only could preclude a rapid return of flexion Time may show that an unnecessary degree of caution has been exercised.

Removal of the nail.—If internal fixation has been used the nail is removed when the requisite degree of mobility has been attained by active means. The forcible flexion of a stiff knee under anaesthesia in order to gain access to the site is liable to provoke undesirable reaction and delay recovery

The scar of the original incision is excised The access required is minimal and the anterior and antero-central attachments of the meniscus should not be disturbed. The nail is extracted by hooking the point of the fine gouge into the groove on the neck using the special tack lifter extractor or using a pair of suitably-pointed dental forceps The deep fixation of the affected area is then tested with the saline moistened gloved forefinger The further treatment, and particularly the decision as to when to permit weight bearing depends on the assessment of the degree of healing determined by radiographs and the visual and digital evidence at operation in relation to the degree of recovery of the quadriceps In general the regime normally applied to the meniscus operation has been employed and a return to weight-bearing permitted about the fourteenth day

Do the nails require to be removed?—The criticism of metal as a form of internal fixation is the apparent need for a second operation to effect removal On the other hand internal fixation in the form described inflicts the minimal damage to the articular surface and is known to provoke no reaction four months from the date of insertion The exploratory operation with the visual evidence of healing it provides has attractions for the surgeon and advantages for the patient But does the nail require to be removed? In one case with a lesion involving half the articular surface of the talus and to which reference is made elsewhere (page 209) a nail was inserted in the knowledge that it could not be recovered without a destructive procedure which would cancel any possible advantage from the original operation The patient is known to have been working as a farm labourer two years later without symptoms If the surgeon's intention is to leave a nail in the femoral condyle permanently

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it would require to be driven flush with the articular surface It is probable that fibrous tissue would fill the groove in the neck and provide fixation Whether such fixation could resist the expelling forces which in the case of knee joint must be present at every step is a matter on which no evidence is available.

Residual joint stiffness —In two cases only has any serious delay in re gaining full flexion been encountered The first was put at rest for twelve weeks following the removal of a torn congenital discoid lateral meniscus associated with a lesion of the adjacent femoral condyle and is the case on which the opinion regarding the attitude to be adopted to such cases is based. Full flexion and virtual perfection of function was eventually attained but only after considerable delay

The second failed to gain more than right-angled flexion two and a half years after operaton The patient (E R female aged 19 H3 Table VII) suffered the condition in both right knee and right hip and is the case referred to in Chapter XIII It is considered that the long continued treatment of the hip was responsible for the stiffness at the knee Examination showed the patella to be freely mobile in all directions and without palpable thickening of the supra-patellar pouch In these circumstances it was anticipated that no difficulty would be encountered in increasing the range of movement by manipulation. Under anaesthesia numerous adhesions in the anterior capsule gave way The manipulation provoked no synovial reaction and with exercise a complete return of flexion was attained.

ERRORS AND OMISSIONS

Exposure.—In the early cases an increase in access was secured by dividing the antero-central and the anterior peripheral attachment of the medial meniscus At the termination of the operation the meniscus was replaced and the securing catgut sutures buried in the fat pad Two patients, several months after a return to full activity reported with symptoms of an internal derangement relative to the medial meniscus. At operation in both cases the anterior segment was torn. This simple and attractive method of improving access to the classical site has therefore been abandoned. It appears that even twelve weeks of immobilisation is insufficient to ensure fixation of the central attachment of this structure which will withstand the trauma of weight-bearing. It should be placed on record that with increasing experience and the use of retractors designed for the purpose the exposure provided by the meniscus incision but without mobilisation of the meniscus has been found to be adequate not only for the purposes of the operation but for securing the photographs which illustrate this text

Preparation of bone.—Experience has shown that there is a tendency particularly marked in the earlier cases of the series to approach the problem with a greater sense of caution than the occasion demands. The object of the operation is the revascularisation of the bony element of the fragment This is possible only if the sclerotic barrier at the floor of the crater is completely broken down The problem differs little whether or not the overlying cartilage is intact. To leave a large dense fragment of bone untouched and the barrier to a new blood supply insufficiently perforated just because the overlying cartilage is intact is to incur the serious risk of failure Returning an unprepared loose body to an unprepared crater and securing it with internal fixation is less than useless it is harmful and can only bring the method into disrepute

Driving and extracting nail.—No difficulty is encountered in driving the nail if the bony element of the fragment has been adequately prepared But if the bone component is large and particularly if the lesion is of some standing, it is almost impenetrable by the nail without the use of unjustifiable force. On one occasion when difficulty in driving was encountered it was not appreciated what had happened to the nail At the second operation no amount of force using the special forceps would move it and it was only as the decision to leave it in situ was made that a bent nail was finally extracted

It is essential when preparation takes place outside the joint, that the loose body be returned to the crater in the manner described in the text so that the direction in which the nail is to be driven can be decided If it is driven through the loose body outside the joint without reference to the angle of access it may be found later that the driving force cannot be applied in the line of entry The nail may thus be bent without the surgeon realising what has occurred This happened on one occasion in a case operated on by a colleague who was unaware of the difficulty When the radiographs were seen some doubt existed as to whether the nail could be extracted at the second operation but it was accomplished without difficulty In this respect it should be noted that the degree of angulation does not necessarily determine the possibility or otherwise of extraction it depends on the hardness of the bone in the fragment at the time of extraction If it is hard a bent nail cannot be withdrawn If it is soft little resistance will be offered (Figs 9, 39 and 9, 40)

On another occasion at the second operation on a case in which two nails had been used the head of one was found to be beneath the surface of the articular cartilage leaving no visual evidence of location It was decided that extraction could be accomplished only with radiographic control and at

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the expense of considerable damage to the virtually perfect surface. The nail was not removed No ill-effects have resulted.

Breaking of penetrating instrument.—On one occasion when a drilling only operation was in progress the tip of an experimental penetrating instrument fractured in the depth of the bone. It could have been recovered only at the expense of the very injury to the articular surface which the operation was designed to prevent. No action was taken The lesion healed and there have been no ill-effects.



Fig. 9, 39



Fig. 9 40

Errors and omissions. The nail may be bent if the base of the crater is inadequately prepared. If the lesion heals in such circumstances, the bent nail may be difficult to extract

EXPERIENCE OF TREATMENT

It is not claimed that the treatment of osteochondritis dissecans of the knee has been finally solved far from it. It is not possible to assess long term results in a condition which in the natural course of events produces traumatic osteoarthritis in greater or lesser period of time depending on such a wide variety of factors. In Table III will be found the record of some thirty cases treated by drilling and some thirty cases treated by drilling and internal fixation The Table provides not only an indication of the variety of the problems presented and the possible opportunities for conservative surgery but some idea of the gradual development of the techniques described.

Every case in which internal fixation was used was explored It is not suggested that all thirty were perfect. But with one exception (P W male aged 23 K91) they had healed. In some early examples inexperience led to inadequate preparation of both crater and loose body with consequent slow incorporation of the bone element. In others arthritis was already advanced It can be claimed however (with the same single exception) to have eliminated the symptoms with which the patient originally reported namely pain instability and recurrent effusions and to have produced visual evidence of restoration of the joint surface even after a loose body had separated.

FUTURE DEVELOPMENTS IN TECHNIQUE OF REPAIR

Preparation of fragment. Accuracy of replacement is of importance Exposed cancellous bone should if possible be avoided Articular cartilage perishes whenever it is in contact with granulation tissue (Landells 1957) The effect of inaccuracy unavoidable in the circumstances of the case is seen in Fig. 9, 10 where exposed bone remained after the replacement of the fragment, some destruction of cartilage at the margin of the loose body is inevitable It is for this reason that it was thought desirable to have a method, other than judgment, of fitting a large hypertrophied free fragment to the prepared crater In any event it is anticipated that a precise method of fitting transplanted bone and articular cartilage to a prepared site will be required in the future. The method envisaged applicable to the refitting of a displaced portion of articular surface or the repair of a defect by graft, is (1) preparation of the crater in the manner described (2) making mould of cavity (3) making positive of cavity from mould (4) fitting of loose body (or transplant) to the positive outside the joint and (5) replacement of loose body in cavity

The time available to complete these manoeuvres is limited. The substance for making mould and positive must fulfil stringent requirements and so far the ideal material has not been found.

Supplementary bone.—In respect of accuracy also experience at exploration of the worst cases in which not sufficient bone was present to support the fragment and in which no additional bone was used suggests that the articular surface becomes flat thereafter and the mechanics of the joint on a long term basis must be altered There is thus a good case for the use of supplementary bone where a suitable bed can be prepared to receive it.

Bone-cartilage grafts.—No solution has been offered in the case untreatable by the methods described. If the crater is large and impossible to repair with the material available an attempt should be made to reproduce the conditions of a fresh osteochondral fracture If all fragments likely to separate are

removed and the sclerotic bone of the base drilled the crater can reasonably be expected to fill with haematoma This will eventually become fibrocartilage which not only seals off the lesion and prevents movement from inflicting injury on the cartilaginous margins but improves the contour of the condyle in the final state

It was circumstances such as these which prompted the suggestion that the affected area might be excised by trephine and replaced by frozen homograft of articular cartilage and bone of suitable surface contour (Smillie 1955) It is of interest that Ehalt (1955) has recorded the replacement by massive bone and cartilage graft of a tuberculous focus in the lower femoral epiphysis of a boy aged five and of the articular surface of the patella for chondromalacia in a woman aged twenty-seven. The possible application to osteochondritis dissecans was mentioned

These ideas have not been pursued in the absence of reliable information regarding the reaction of articular cartilage to freezing If the nutritional requirements of bone and cartilage are anticomplementary it appears that the physical conditions in which they can be preserved are also at variance. But when the difficulties of securing, preparing and storing such material have been overcome a spectacular advance in the treatment of many more diseases than osteochondritis dissecans will be possible

In the present state of knowledge autogenous bone-cartilage grafting is a less questionable procedure The occasional opportunity may arise in a bilateral case for example to transfer a loose body from one knee to repair a defect in the other This situation is possible when a fragment has been separated for some time and in which repair of the original condyle proves unjustifiable The loose body instead of being discarded, might be used for the repair of a less far advanced lesion in the second knee

Large loose bodies with smooth cartilage have been preserved on two occasions for possible use in the second knee In neither case when the time came was the use of the autogenous material justifiable The point is made however that the situation could arise when the use of such material might result in the saving of the second knee

If the opportunity to follow the suggestions of 1955 and transplant a bone-cartilage graft to repair an osteochondritis dissecans lesion has not arisen in the series reported (Table III) it has been successfully accomplished by Bado (1956) using a graft taken from the opposite patella At exploration to remove the screws used for fixation six months later the cartilage was " normal in color and consistency " The circumstances in which this source of autogenous graft is justifiable must be uncommon but what was theoretically possible has been proved to be of practical application

TABLE III

	Sex	*Age*	*R or L*	*Site*	*Variety*	*Treatment*	*Result*	*Notes*
	M	20	R	Classical medial condyle	Probably juvenile	Operation removal of loose body from crater	Unknown	Could have been repaired
	M	59	R	Not determined	Adult	Operation removal of loose body from posterior compartment	Symptoms relieved	
	M	27	R	Classical medial condyle	Adult	R—Operation removal of loose bodies from crater	Relief of locking symptoms	Right side—Evidence of contact lesion in both eminences of tibial spine. Gross osteo-arthritis.
			L	Classical medial condyle		L—Observation		Left—Less affected joint, but osteoarthritis
	M	21	L	Not determined	Probably adult	Operation removal of loose body	Relief of locking symptoms	Loose body looked like osteochondral fracture from lateral aspect lateral femoral condyle
	M	49	R	Classical medial condyle	Adult	Operation removal of multiple loose bodies through para patellar incision	Relief of immediate locking symptoms	First loose body removed at age 25 Trouble ever since. Now gross osteoarthritis and multiple loose bodies emanating from original site Could probably have been repaired at original operation
5	M	27	R	Classical medial condyle	Probably juvenile	Operation loose body removed from crater R—removed 1944	Long term result unknown	Example of case in which repair could have been effected Very large lesion blunted medial eminence of tibial spine
			L	Classical medial condyle		L—removed 1934		
7	M	32	L	Classical medial condyle	Adult	Operation removal of loose bodies excision of medial *meniscus*	Relief of symptoms long-term result unknown	Osteochrondritis dissecans probably secondary to meniscus lesion
.8	M	18	L	Classical medial condyle	Juvenile	Operation removal of fragment from crater		Could have been repaired

TABLE III (*continued*)

No	Sex	Age	R or L	Site	Variety	Treatment	Result	Notes
9	M	26	L	Classical medial condyle	Juvenile	Operation excision of a very large fragment from crater	Long-term result unknown	Could have been repaired
10	M	40	L	Classical medial condyle	Adult	Operation removal of loose body and medial meniscus	Relief of symptoms long-term result unknown	Secondary to tear medial meniscus
11	M	25	L	Classical medial condyle	Adult	Operation removal of large fragment from crater	Long-term result unknown	Could have been repaired
12	M	39	R	Not determined ?lateral aspect lateral condyle	Adult	Operation removal of loose body from posterior compartment	Symptoms relieved	Definite injury three years previously Probable tangential osteochondral fracture lateral condyle
13	M	61	R	Classical medial condyle	Adult	Operation removal of multiple loose bodies	Relief of immediate locking symptoms	Contact lesion medial eminence tibial spine and femoral condyle result of degenerative changes of long standing
14	M	27	R	Classical medial condyle	Adult	Operation removal of loose body from posterior compartment	Relief of symptoms	Definite history of injury four years previously Anterior cruciate rupture. Contact lesion tibial spine
15	M	32	R	Classical medial condyle	?Juvenile	Operation removal of loose fragment from crater		Could have been repaired. Osteochrondritis dissecans of left capitellum also with loose body formation
16	M	14	L	Classical medial condyle	Juvenile Adult	Operation drilling excision of torn discoid lateral meniscus	Healed clinically and radiologically	Probably related to torn discoid meniscus as a result of instability
17	M	34	L	Classical medial condyle	Adult	Operation removal of loose bodies. Excision torn medial meniscus	Relief of immediate symptoms	Twenty years history of injury Condition secondary to old meniscus injury and worn joint

TABLE III (*continued*)

Sex	*Age*	*R or L*	*Site*	*Variety*	*Treatment*	*Result*	*Notes*
M	25	R	Lateral aspect lateral condyle	Adult	Operation removal of loose body	Relief of locking symptoms	Football injury at age 22 Probable osteochondral fracture lateral condyle
M	20	L	Medial aspect patella	Adult	Operation removal of loose body	Immediate symptoms relieved	Unlikely to be true osteochondritis dissecans Probably tangential osteochondral fracture
M	24	R	Classical medial condyle	Probably juvenile	R—Observation		Gross osteoarthritis both knees
		L	Classical medial condyle		L—Operation removal of five loose bodies		
M	25	R	Classical medial condyle	Probably juvenile	R—Operation removal of loose body 2"x1"	Long-term result unknown	Very large lesions both medial femoral condyles both could have been repaired History dating to age 16
		L	Classical medial condyle		L—Operation removal of two loose bodies, each 1"x½"		
M	22	R	Probably lateral aspect lateral condyle	Adult	Operation removal of loose body	Relief of locking	Probable osteochondral fracture lateral femoral condyle
M	30	R	Classical medial condyle	Juvenile	R—Observation	R—Unknown	Gross bilateral genu varum and coxa vara. General bone disease of undetermined origin. Deformity upper tibial epiphysis
		L	Classical medial condyle		L—Operation removal of loose body	L—Relief of locking	
M	27	L	Classical medial condyle	Probably juvenile	Operation removal of two large loose bodies	Relief of locking symptoms	Ten years history of symptoms
M	48	R	Classical medial condyle	Adult	Operation removal of loose bodies	Relief of locking	Probably secondary to osteoarthritis. *Gross osteoarthritis*. Football injury twenty-five years previously
F	15	L	Classical medial condyle	Juvenile	Operation large loose body removed from crater	Long-term result unknown	Could have been repaired

TABLE III (*continued*)

Case No	Sex	Age	R or L	Site	Variety	Treatment	Result	Notes
K27	F	50	R	Classical medial condyle	Adult	Operation removal of loose body	Relief of locking symptoms	Osteoarthritis secondary to osteochondritis dissecans
K28	F	19	R	Classical medial condyle	Probably juvenile	Operation removal of two loose bodies	Relief of locking symptoms	Five years history of knee symptoms
K29	M	31	L	Uncertain—probably lateral aspect lateral condyle	Adult	Operation removal of two loose bodies	Relief of locking	This case, with two large recent loose bodies 1 square could have been repaired without difficulty
K30	F	19	R	Lateral aspect lateral condyle	Adult	Operation removal of very large loose body	Relief of locking symptoms	Abnormal knee joints in that patella exceptionally high. Could have been repaired
K31	M	39	R L	Classical medial condyle Classical medial condyle	Uncertain—possibly adult	R—Operation removal of loose body L—Operation removal of two loose bodies at age 21	Relief of locking	Osteoarthritis both knees, particularly left Loose body had been free in right knee for at least six years before operation
K32	M	36	L	Lateral condyle	Adult	Operation removal of loose bodies from crater		Osteoarthritis, bilateral genu varum Osteochondritis dissecans probably secondary to this deformity
K33	M	21	R	Classical medial condyle	Adult	Operation removal of large loose body	Relief of locking symptoms	Could have been repaired. Anterior cruciate ligament ruptured and the fragment could have been fractured by internal trauma as a result of instability
K34	F	20	R	Classical medial condyle	?Adult	Operations loose bodies removed on two occasions at 6-months interval		All loose bodies not found and crater not inspected at first operation
K35	F	50	R	Classical medial condyle	Adult	Operation removal of loose bodies	Relief of locking	*Gross arthritis both knees secondary to overweight Lesion secondary to degenerative changes*

TABLE III (*continued*)

Sex	*Age*	*R or L*	*Site*	*Variety*	*Treatment*	*Result*	*Notes*
M	—	R	Classical medial condyle	?Adult	Operation drilling and replacement of fragment without internal fixation	Clinical excellent	Working as miner one year later Lesion healing in radiograph but site still discernible
M	16	R	Classical medial condyle	Juvenile	Operation drilling	Healed clinically and radiologically No symptoms	At operation articular cartilage intact but soft to touch
M	16	R	Classical medial condyle	Juvenile	Operation drilling	Healed clinically and radiologically No symptoms	At operation articular cartilage intact but soft to touch
M	15	R	Patella	?Adult	Operations three loose bodies removed on three separate occasions	Relief of locking symptoms	The origin of this case is obscure Known to have been run over by an automobile at age 7 with multiple fractures
M	35	R	Classical medial condyle	Adult	Operation removal of loose bodies		Secondary to loss of joint space and subsequent impingement of tibial spine
F	22	R	Classical medial condyle	Probably juvenile	Operation removal of large loose body	Relief of locking symptoms	Four years history of locking. Loose body must have separated at age 18
F	47	L	Lateral aspect lateral condyle	Adult	Observation		Bilateral valgus deformity of knees with laterally displaced patellae Fragment probably shorn off by dislocating patella Gross osteoarthritis
M	38	R	Classical medial condyle	Adult	Observation		Grossly overweight man with four small loose bodies from classical site Lesion secondary to wear and tear and impingement of tibial spine
F	15	R	Lateral aspect lateral condyle	Adult	Operation drilling and internal fixation with vitallium screw	Healed by observation. Healed radiologically No symptoms	Massive fragment loose in joint at least six weeks. Thought to have been displaced as a result of twist playing hockey

TABLE III (*continued*)

Case No	*Sex*	*Age*	*R or L*	*Site*	*Variety*	*Treatment*	*Result*	*Notes*
K45	M	17	L	Centre lateral condyle	Uncertain possibly juvenile	Operation removal of loose body	Relief of locking symptoms	Loose body located beneath medial meniscus
K46	F	66	R	Lateral condyle	Adult	Operation removal of loose body from supra patellar pouch		Gross osteoarthritis lesion secondary to impingement lateral eminence tibial spine which had fractured in the process
K47	M	19	L	Classical medial condyle	Probably juvenile	Operation excision of fragment from crater	Relief of immediate giving-way symptoms	Evidence of contact in tibial spine. Could have been repaired
K48	M	19	L	Posterior aspect medial condyle	Adult	Operation removal of loose body and torn lateral meniscus	Relief of immediate symptoms	Thought to be secondary to torn lateral meniscus of 1½ years duration
K49	M	44	L	Classical medial condyle	Adult	Operation removal of loose body	Relief of locking symptoms	Gross arthritis. Loose body probably secondary to degenerative changes. History of gross injury to knee in motor-cycle accident at age 25
K50	M	13	R	Lateral condyle	Juvenile	Operation removal of loose body	Relief of locking symptoms	Probably tangential osteochondral fracture produced by patella in simple twisting injury eight weeks previously. Very tall boy for age. Bilateral pes cavus. Dysostotic constitution
K51	M	29	R	Centre lateral condyle	Adult	Operation drilling	Healed clinically and radiologically	Directly secondary to complete longitudinal tear lateral meniscus and torn cruciate ligament
K52	M	47	L	Classical medial condyle	Adult	Operation removal of three loose bodies	Relief of locking symptoms	Osteoarthritis. Origin probably contact lesion tibial spine
K53	M	37	L	Classical medial condyle	Adult	Operation excision of medial meniscus removal of two loose bodies	Relief of locking symptoms	Directly secondary to complete longitudinal tear medial meniscus and rupture anterior cruciate ligament. Impingement lesion by tibial spine

TABLE III (*continued*)

Case No	Sex	Age	R or L	Site	Variety	Treatment	Result	Notes
K54	M	54	L	Medial aspect lateral condyle	Adult	Operation removal of loose body	Relief of locking symptoms	Gross arthritis. Meniscus tear thirty years ago untreated Impingement lesion lateral condyle tibial spine with flattening
K55	M	41	R	Classical medial condyle	Adult	Operation removal of loose body	Relief of locking symptoms	Medial meniscus torn ten years ago Rupture anterior cruciate ligament. Gross osteoarthritis
K56	M	25	L	Classical medial condyle	Adult	Operation removal of loose body	Relief of locking symptoms	Football injury two years previously Probably contact lesion tibial spine
K57	M	47	L	Classical medial condyle	Adult	Operation loose body excised from crater	Relief of pain and recurrent effusions	Could have been repaired but for age and osteoarthritic changes. Lesion probably nine years old
K58	F	32	L	Classical medial condyle	Adult	Operation removal of two loose bodies	Relief of locking symptoms	R. side evidence of contact lesion in both eminences of tibial spine. Gross osteoarthritis. L. less affected joint but osteoarthritis
K59	M	14	R	Classical medial condyle	Juvenile	R—Operation removal of two loose bodies from crater	R—Relief of symptoms	R side probably could have been repaired
			L	Classical medial condyle		L—Operation drilling	L—Healed radiologically and clinically	
K60	M	47	R	Classical medial condyle	Adul	Operation removal of two loose bodies from posterior compartment	Relief of locking symptoms	Meniscus injury untreated twenty-seven years previously Osteochondritis dissecans lesion secondary to degenerative changes Gross osteoarthritis
K61	M	34	L	Classical medial condyle	Uncertain	Operations loose bodies removed on two occasions at interval of 11 years	Relief of locking symptoms	Example of case in which large loose bodies shed into joint at long intervals Probably could have been repaired at original operation
K62	F	10	R	Classical medial condyle	Juvenile	R—Operation drilling	Healed radiologically healed clinically	
			L	Classical medial condyle		L—Operation drilling		

TABLE III (*continued*)

Case No	Sex	Age	R or L	Site	Variety	Treatment	Result	Notes
K45	M	17	L	Centre lateral condyle	Uncertain, possibly juvenile	Operation removal of loose body	Relief of locking symptoms	Loose body located beneath medial meniscus
K46	F	66	R	Lateral condyle	Adult	Operation removal of loose body from supra patellar pouch		Gross osteoarthritis lesion secondary to impingement lateral eminence tibial spine which had fractured in the process
K47	M	19	L	Classical medial condyle	Probably juvenile	Operation excision of fragment from crater	Relief of immediate giving-way symptoms	Evidence of contact in tibial spine. Could have been repaired
K48	M	19	L	Posterior aspect medial condyle	Adult	Operation removal of loose body and torn lateral meniscus	Relief of immediate symptoms	Thought to be secondary to torn lateral meniscus of 1½ years duration
K49	M	44	L	Classical medial condyle	Adult	Operation removal of loose body	Relief of locking symptoms	Gross arthritis. Loose body probably secondary to degenerative changes. History of gross injury to knee in motor-cycle accident at age 25
K50	M	13	R	Lateral condyle	Juvenile	Operation removal of loose body	Relief of locking symptoms	Probably tangential osteochondral fracture produced by patella in simple twisting injury eight weeks previously. Very tall boy for age. Bilateral pes cavus. Dysostotic constitution
K51	M	29	R	Centre lateral condyle	Adult	Operation drilling	Healed clinically and radiologically	Directly secondary to complete longitudinal tear lateral meniscus and torn cruciate ligament
K52	M	47	L	Classical medial condyle	Adult	Operation removal of three loose bodies	Relief of locking symptoms	Osteoarthritis. Origin probably contact lesion tibial spine
K53	M	37	L	Classical medial condyle	Adult	Operation excision of medial meniscus removal of two loose bodies	Relief of locking symptoms	Directly secondary to complete longitudinal tear medial meniscus and rupture anterior cruciate ligament. Impingement lesion by tibial spine

TABLE III (*continued*)

Sex	*Age*	*R or L*	*Site*	*Variety*	*Treatment*	*Result*	*Notes*
M	54	L	Medial aspect lateral condyle	Adult	Operation removal of loose body	Relief of locking symptoms	Gross arthritis. Meniscus tear thirty years ago untreated. Impingement lesion lateral condyle tibial spine with flattening
M	41	R	Classical medial condyle	Adult	Operation removal of loose body	Relief of locking symptoms	Medial meniscus torn ten years ago. Rupture anterior cruciate ligament. Gross osteoarthritis
M	[illegible]	L	Classical medial condyle	Adult	Operation removal of loose body	Relief of locking symptoms	Football injury two years previously. Probably contact lesion tibial spine
M	47	L	Classical medial condyle	Adult	Operation loose body excised from crater	Relief of pain and recurrent effusions	Could have been repaired but for age and osteoarthritic changes. Lesion probably nine years old
F	32	L	Classical medial condyle	Adult	Operation removal of two loose bodies	Relief of locking symptoms	R. side evidence of contact lesion in both eminences of tibial spine. Gross osteo-arthritis. L. less affected joint but osteoarthritis
M	14	R	Classical medial condyle	Juvenile	R—Operation removal of two loose bodies from crater	R—Relief of symptoms	R. side probably could have been repaired
		L	Classical medial condyle		L—Operation drilling	L—Healed radiologically and clinically	
M	47	R	Classical medial condyle	Adu.	Operation removal of two loose bodies from posterior compartment	Relief of locking symptoms	Meniscus injury untreated twenty-seven years previously. Osteochondritis dissecans lesion secondary to degenerative changes. Gross osteoarthritis
M	34	L	Classical medial condyle	Uncertain	Operations loose bodies removed on two occasions at interval of 11 years	Relief of locking symptoms	Example of case in which large loose bodies shed into joint at long intervals. Probably could have been repaired at original operation
F	10	R	Classical medial condyle	Juvenile	R—Operation drilling	Healed radiologically healed clinically	
		L	Classical medial condyle		L—Operation drilling		

TABLE III (*continued*)

Case No	Sex	Age	R or L	Site	Variety	Treatment	Result	Notes
K63	M	15	R	Classical medial condyle	Juvenile	Operation drilling	Healed radiologically and clinically	
K64	M	17	R L	Medial aspect lateral condyle Medial aspect lateral condyle	Juvenile	R—Operation loose body removed L—Observation	R—Relief of locking symptoms	Probably arose in anomalies of ossification. Misdiagnosed as tuberculous elsewhere three years previously
K65	M	16	R	Classical medial condyle	Juvenile	Operation removal of loose body		Probably could have been repaired
K66	M	17	L	Classical medial condyle	Juvenile	Operation drilling	Completely healed radiologically six months later Symptoms of giving-way eliminated	Very large radiological lesion articular surface unbroken
K67	M	53	R	Classical medial condyle	Adult	Operation excision of meniscus	No direct symptoms relating to lesion	Secondary to complete longitudinal tear medial meniscus
K68	M	22	L	Classical medial condyle	Probably adult	Operation removal of loose bodies	Relief of locking	No repair possible Loose bodies been separated for at least two months
K69	M	25	L	Classical medial condyle	Adult	Observation		Several loose bodies from defect medial femoral condyle Contact lesion due to degenerative changes secondary to untreated medial meniscus injury
K70	M	19	R	Classical medial condyle	Juvenile	Operation drilling and internal fixation with vitallium screw	Healed by observation Healed radiologically Symptomless	Very large fragment probably completely free six weeks previous to operation
K71	M	20	L	Classical medial condyle	Juvenile	Operation loose body removed	Relief of locking	

TABLE III (*continued*)

Case No	Sex	Age	R or L	Site	Variety	Treatment	Result	Notes
K72	M	27	L	Classical medial condyle	Adult	Operation excision medial meniscus smoothing of cartil age at site of lesion	Relief of immediate symptoms due to meniscus tear	This was a lesion involving articular cartilage only and was a contact lesion from tibial spine result of instability from rupture of *posterior cruciate ligament* and tear posterior horn medial *meniscus*
K73	M	13	R	Classical medial condyle	Juvenile	Operation drilling, plaster cast	Healed clinically and radiologically	
K74	M	45	R	Classical medial condyle	Adult	Operation removal of loose body	Relief of locking	Gross osteoarthritis
K75	M	18	L	Classical medial condyle	Probably adult	Operation drilling and internal fixation plaster cast	Seen to be healed at exploration. Healed clinically and radiologically	Case referred to in text where nails like ordinary commercial pins were used. Back knee High patella
K76	M	4[illegible]	L	Classical medial condyle	Adult	Operation removal of loose bodies	Relief of locking	Gross osteoarthritis. Osteo-chondritis dissecans secondary to osteoarthritis
K77	M	62	L	Classical medial condyle	Uncer tain	Operation removal of loose bodies	Relief of locking	Gross osteoarthritis secondary to osteochondritis dissecans in youth
K78	F	22	R	Classical medial condyle	Adult	R—Opera tion drilling, plaster cast	R—Healed clinically and radiologically	Bilateral deformity of tibial table. Table flat. Evidence premature closure anterior aspect upper tibial epiphysis
			L	Classical medial condyle		L—Opera tion drilling and internal fixation plaster cast	L—Seen to be healed at explora tion. Healed clinically and radiologically	
K79	M	14	R	Classical medial condyle	Juvenile	R—Opera tion drilling plaster cast	R—Healed clinically and radiologically	Articular cartilage unfractured both sides but site detectable by groove or indentation
			L	Classical medial condyle		L—Opera tion drilling plaster cast	L—Healed clinically and radiologically	
K80	F	13	R	Classical medial condyle	Juvenile	Operation drilling plaster cast	Healed clinically and radiologically	Articular surface intact but fracture open to intercondylar notch

TABLE III (*continued*)

Case No	Sex	Age	R or L	Site	Variety	Treatment	Result	Notes
K81	F	19	R	Classical medial condyle	Juvenile	Operation drilling and internal fixation with two nails	Healed at exploration healed clinically and radiologically	Required manipulation to attain full flexion. This patient later developed a lesion in the R. hip and is the case subjected to conservative surgery and referred to in text. Excessively heavy girl. Constitutional form of endocrine dysfunction (Case H3 Table VII)
K82	M	20	R	Classical medial condyle	Adult	Operation drilling and internal fixation	Healed at exploration four months later healed clinically and radiologically	Slow radiological healing due probably to inadequate preparation of crater and bony element of fragment
K83	F	27	R	Lateral aspect lateral condyle	Adult	Operation removal of loose body		External rotation injury one month previously Osteo-chondral fracture probably displaced by patella. Premature closure of upper tibial epiphysis
K84	M	19	L	Classical medial condyle	?Adult	Operation removal of loose body	Relief of locking	Loose body in suprapatellar pouch probably been separated at least six months
K85	M	10	R	Centre medial condyle	?Juvenile	R—Operation drilling	R—Healed clinically and radiologically	It was questionable whether the R knee had progressed from anomaly of ossification to osteochondritis dissecans when drilling was carried out
			L	Centre medial condyle	?Anomaly of ossification	L—Operation torn meniscus removed	L—Healed clinically and radiologically	
K86	M	14	R	Classical medial condyle	?Adult	Operation drilling plaster cast	Healed clinically and radiologically	Uncertain whether this case arose in anomaly of ossification or whether it was of purely mechanical origin
K87	M	16	R	Lateral condyle	Adult	Operation removal of torn congenital meniscus drilling and internal fixation	Healed at exploration Healed radiologically	Example of adult variety osteochondritis dissecans in a youth of mechanical origin due to presence of torn congenital discoid meniscus
K88	F	48	R	Classical medial condyle	Adult	Operation removal of loose body	Relief of locking	Gross osteoarthritis. Osteo-chondritis dissecans effect not cause
K89	M	76	R	Classical medial condyle	Adult	Observation		Recent lesion occurring at age 76 result of contact between medial eminence of tibial spine and condyle

TABLE III (*continued*)

Case No	Sex	Age	R or L	Site	Variety	Treatment	Result	Notes
K90	M	32	R	Classical medial condyle	?Adult	R—Operation removal of two loose bodies	R—No symptoms	This is the patient referred to in the text who following a dashboard fracture of the R. patella, unexpectedly regained a normal range of flexion as a result of the presence of the loose bodies
			L	Classical medial condyle		L—Operation removal of loose body	L—Relief of locking	
K91	M	23	R	Classical medial condyle	?Adult	Operation drilling and internal fixation	Area soft at exploratory operation Not healed radiologically when last seen	This patient walked on the knee throughout treatment and it is not known whether the softness of the articular cartilage seen on extraction of the nail was due to this cause or not. Only unsatisfactory case noted to date
K92	F	11	R	Classical medial condyle	Juvenile	R—Operation drilling	Both sides healed clinically and radiologically	Originally anomalies of ossification
			L	Classical medial condyle		L—Immobilisation		
K93	M	18	L	Classical medial condyle	?Adult	Operation drilling and internal fixation plaster cast	Healed at exploratory operation healed clinically and radiologically	Not known whether this arose in anomaly of ossification or mechanical from contact with tibial spine
K94	M	18	R	Lateral aspect lateral condyle	Adult	Operation removal of loose body	Relief of locking symptoms	This case almost certainly arose as a result of a kick on the lateral aspect of lateral femoral condyle at a football game The loose body was found beneath the meniscus
K95	M	59	R	Classical medial condyle	Adult	Operation removal of loose bodies	Relief of locking	Meniscectomy thirty years ago Gross osteoarthritis. Osteochondritis dissecans secondary to osteoarthritis
K96	M	22	L	Lateral aspect lateral condyle	Adult	Operation replacement of loose body and internal fixation using two nails	Healed at exploratory operation healed clinically and radiologically	Completely free loose body 2"x1" from lateral aspect lateral femoral condyle. Almost certainly the result of direct violence: an osteochondral fracture
K97	M	60	L	Classical medial condyle	Adult	Operation removal of loose bodies	Relief of locking	Gross osteoarthritis. Osteochondritis dissecans secondary to osteoarthritis

TABLE III (*continued*)

Case No	*Sex*	*Age*	*R or L*	*Site*	*Variety*	*Treatment*	*Result*	*Notes*
K98	M	26	R	Classical medial condyle	Adult	Operation drilling and internal fixation with two pins	Healed radiologically	Loose body completely free, 2 x1" Injury seven years previously Degenerative changes. Not known whether lesion result of injury or of contact lesion following degenerative changes
K99	M	57	R	Classical medial condyle	Adult	Observation	Symptoms of arthritis both sides	Gross osteoarthritis. Lesion probably secondary to loss of joint space
			L	Classical medial condyle				
K100	F	34	R	Lateral condyle	Adult	Operation removal of loose body	Relief of locking	
K101	M	35	R	Classical medial condyle	Adult	Operation removal of loose body	Relief of locking symptoms	This patient had medial and lateral meniscectomies and has gross wear and tear producing reduction in joint space and contact between tibial spine and femoral condyle
K102	M	56	R	Classical medial condyle	Adult	Operation removal of loose bodies	Relief of locking; symptoms of arthritis	Gross osteoarthritis. Osteochondritis dissecans secondary to osteoarthritis
K103	M	12	R	Classical medial condyle	Juvenile	R—Plaster immobilisation	Healed clinically and radiologically	*This is a probable example of bilateral anomalies of ossification at the precursor stage rather than established osteochondritis dissecans*
			L	Classical medial condyle		L—Observation		
K104	M	31	R	Classical medial condyle	Adult	Operation drilling and internal fixation	Healed at second operation healed clinically and radiologically	Back knee deformity lesion thought to have been of mechanical origin Condition of some duration—osteoarthritis already present at time of operation
K105	M	31	R	Classical medial condyle	Adult	R—Operation removal of three loose bodies	R—Relief of locking symptoms	This patient had a torn lateral meniscus removed from the L. knee prior to the lesion being discovered. The meniscus lesion is unlikely to be related to the osteochondritis dissecans which was bilateral
			L	Classical medial condyle		L—Operation removal of loose bodies	L—Relief of locking symptoms	

TABLE III (*continued*)

?	Sex	Age	R or L	Site	Variety	Treatment	Result	Notes
06	M	24	R	Lateral aspect lateral condyle	Adult	Operation drilling and internal fixation	Healed at exploratory operation healed clinically and radiologically Superimposed arthritic changes prejudiced perfection in final result	This is probably an example of an injury to the lateral aspect of the lateral femoral condyle of ?eight years standing in which the cartilage did not give way entirely at the initial injury
07	M	19	R	Centre medial condyle	Juvenile	R—Operation removal of loose body	R—Relief of locking	This patient, 5 1" tall, looked like achondroplasia Gross hyperextension both knees. Marked example dysostotic constitution
			L	Centre medial condyle		L—Operation removal of loose body	L—Relief of locking	
108	M	68	R	Classical medial condyle	Adult	Operation removal of loose body	Relief of locking symptoms	Osteoarthritis. Old meniscus tear Osteochondritis dissecans secondary to loss of joint space
109	F	51	R	Classical medial condyle	Adult	Operation removal of fragment from crater	Symptoms of arthritis	Osteochondritis not primary secondary to loss of joint space from wear and tear
110	M	39	L	Classical medial condyle	Adult	Operation removal of loose body	Relief of locking symptoms	Degenerative changes secondary to menisectomy twenty years previously
111	M	18	L	Classical medial condyle	Probably juvenile	Operation drilling and internal fixation with two nails	Healed at second operation healed clinically	Massive bony element not completely incorporated when last seen probably due to inadequate preparation of fragment
112	M	17	R	Classical medial condyle	Probably juvenile	Operation drilling	Healed clinically and radiologically	
113	F	1?	R	Centre lateral condyle	Adult	Conservative patten and crutches following removal torn congenital disc	Healed clinically and radiologically	Example of adult variety in child

TABLE III (*continued*)

Case No	Sex	Age	R or L	Site	Variety	Treatment	Result	Notes
K114	F	17	R	Classical medial condyle	Probably juvenile	Operation drilling and internal fixation with two nails	Healed at second operation healed clinically and radiologically	This is a case in which one of the two nails could not be recovered at the second operation and was left in situ
K115	M	38	R	Medial margin lateral condyle	Adult	R—Expectant		Arthritic change already advanced
			L	Classical medial condyle		L—Operation drilling and internal fixation	L—Healed at exploration healed clinically and radiologically	
K116	F	19	L	Lateral aspect lateral condyle	?Juvenile ?Adult	Operation drilling and internal fixation with two nails	Healed at second operation, healed clinically and radiologically	Massive fragment on posterior lateral aspect femoral condyle not known whether it was of traumatic origin or not
K117	F	21	L	Classical medial condyle	Adult	Operation drilling and internal fixation	Healed at exploration healed clinically and radiologically	Back-knee the result of illness necessitating prolonged bed-rest in early youth. Lesion of mechanical origin. Patient teacher of dancing
K118	M	20	R	Classical medial condyle	?Juvenile ?Adult	Operation drilling and internal fixation	Healed at exploration healed clinically and radiologically	Fragments used for repair had been trapped on numerous occasions and the surface was imperfect
K119	M	14	R	Classical medial condyle	Juvenile	Operation drilling	Healed clinically and radiologically	Articular cartilage unfractured but could be indented with pressure Horizontal cleavage lesion demonstrated with angled probe. Height 6 ft heavy in proportion
K120	M	30	R	Classical medial condyle	Adult	Operation drilling	Clinically good	This case was of long standing with some secondary arthritic change Still possible to detect outline of fragment in radiograph
K121	M	23	L	Classical medial condyle	?Juvenile	None accepted		Very large lesion of long standing recently separated
K122	M	41	L	Lateral aspect lateral condyle	Adult	Operation drilling and internal fixation with two nails	Healed at exploration healed clinically and radiologically but imperfect	Fragment probably partially detached eight years previously History of trauma. Perfection unobtainable in view of length of history

TABLE III (*continued*)

Case No	Sex	Age	R or L	Site	Variety	Treatment	Result	Notes
K123	M	22	L	Classical medial condyle	Adult	Operation removal of loose body	Relief of locking symptoms	Medial meniscectomy five years previously Certain contact lesion by observation at original operation
K124	M	12	L	Classical medial condyle	Juvenile	Operation drilling and internal fixation	Healed by observation at second operation	
K125	M	22	R	Classical medial condyle	Probably juvenile	Operation drilling	Clinical result good not perfect because of previous arthritis	Drill broken and left in condyle; still possible to distinguish outline bony element six months later
K126	M	22	L	Medial aspect patella	Not deter mined	Operation removal of loose bodies	Relief of locking	Etiology not determined, but known rugby football injury four months previously
K127	M	42	R	Classical medial condyle	Adult	Operation removal of loose body	Relief of locking symptoms of arthritis	Contact lesion due to old untreated torn medial meniscus of twenty years duration
K128	M	57	L	Classical medial condyle	Adult	Operation removal of loose body	Relief of locking	Gross osteoarthritis. Lesion secondary to loss of joint space Well-marked impingement of tibial spine. Tibial spine flattened
K129	M	29	R	Centre medial condyle	Adult	Operation drilling and internal fixation	Healed at exploratory operation, healed clinically and radiologically Not perfect because of degenerative changes	Bony element was incorporated but some deformity of the condyle remained Joint was already the subject of degenerative changes before operation
K130	F	11	R	Classical medial condyle	Juvenile	R—Operation drilled	R—Healed clinically and radiologically	Originally anomaly of ossification which proceeded to osteochondritis dissecans
			L	Classical medial condyle		L—Rest—failed to heal. Later operation drilled	L—Healed clinically and radiologically	

TABLE III (*continued*)

Case No	Sex	Age	R or L	Site	Variety	Treatment	Result	Notes
K131	M	12	R	Centre lateral condyle	Juvenile	R—Operation drilled from lateral side	R—Healed clinically and radiologically	R—Undoubtedly pathological lesion which healed following operation
			L	Centre lateral condyle	Anomaly of ossification	L—Observation	L—Anomaly disappeared	L—Probably precursor stage. Treated by observation in view of tendency to healing in lateral condyle
K132	F	51	R	Classical medial condyle	Adult	Observation		Gross osteoarthritis. Fragment not separated. Lesion secondary to loss of joint space
K133	M	41	R	Lateral condyle	Adult	Observation		Osteoarthritis is probably primary. Possibility of underlying meniscus tear
K134	M	13	L	Classical medial condyle	Juvenile	Operation drilled from medial side	Returned to normal radiologically and clinically in six months	Anomaly of ossification. Excessively heavy boy
K135	M	42	R	Classical medial condyle	Adult	Operation removal of loose bodies	Relief of locking symptoms	Gross osteoarthritis secondary to lesion
K136	F	25	L	Classical medial condyle	?Adult	Operation drilling and internal fixation	Lesion healed at second operation healed radiologically and symptomless one year later	Late case: some arthritis change already present
K137	M	34	R	Patella	?Adult	Operation removal of loose body	Relief of locking	Short stature back knee high patella. Probable tangential osteochondral fracture ten years previously
K138	F	61	L	Lateral aspect lateral condyle	Adult	Operation removal of loose bodies	Relief of locking; symptoms of arthritis	Osteochondritis dissecans not primary lesion, secondary to wear and tear changes
K139	M	18	R	Lateral aspect lateral condyle	Adult	Operation removal of three loose bodies	Relief of locking	Blow on lateral aspect of knee nine months previously. Lesion impossible to repair with material available

TABLE III (*continued*)

Age	*R or L*	*Site*	*Variety*	*Treatment*	*Result*	*Notes*
48	L	Classical medial condyle	?Juvenile	Operations loose body removed aged 19 loose body removed aged 32		Now advanced osteoarthritis. This is a case which could have been repaired
12	L	Lateral aspect lateral condyle	Adult	Operation loose body returned to crater secured with internal fixation	Noted to be healed at second operation healed clinically and radiologically	Blow lateral aspect of knee three weeks previously
19	L	Lateral aspect lateral condyle	Juvenile	Operation removal of loose body	Relief of locking symptoms	Osteochondral fracture produced by patella. Hormonal dysfunction Said to be primary S.F.H failure. Under treatment and said to have been much improved by implantation therapy
14	L	Centre medial condyle	Juvenile	Operation drilling from medial side	Radiologically healed in four months. Symptomless	Originally anomaly of ossification Height 5 10" at age 14 heavy in proportion
15	L	Lateral aspect lateral condyle	Adult	Operation removal of loose body	Symptoms of arthritis	Gross osteoarthritic changes closure of anterior aspect lateral tibial condyle result of transplantation of tibial tubercle for recurrent subluxation patella Loose body originated lateral margin lateral condyle not centre lateral condyle
21	L	Classical medial condyle	?Adult	Operation removal of loose body 1¼"x¼"		Definite history of injury six years previously Crater smoothed off Secondary arthritic changes repair unjustified

TABLE III (*continued*)

Case No	*Sex*	*Age*	*R or L*	*Site*	*Variety*	*Treatment*	*Result*	*Notes*
K146	M	20	R	Patella	Juvenile	R. Patella—Operation removal of loose body: smoothing of crater	R—Relief of patella symptoms	Height 5 1 Dysostotic constitution. Combination of bilateral osteochondritis dissecans of patella affecting middle zone of both patellae and classical site and 1¼ x1 lesion of medial condyle
			L	Patella		L. Patella—Operation removal of loose body: smoothing of crater	L—Relief of patella symptoms	
			L	Classical medial condyle		L. Medial condyle—Operation drilling and internal fixation	L. Femoral condyle healed at second operation healed clinically and radiologically	
K147	M	37	L	Classical medial condyle	Adult	Observation		Secondary to meniscectomies. Medial meniscectomy 1950. Congenital discoid lateral 1958
K148	M	27	R	Classical medial condyle	Adult	Observation		Secondary to horizontal cleavage lesion medial meniscus
K149	F	16	L	Classical medial condyle	?Juvenile ?Adult	Operation drilling and internal fixation	Healed at exploration healed radiologically but area flat compared with general contour of condyle	Advanced case for age with evidence of osteoarthritis. Large loose body 1¼"x¾ Probably adult variety secondary to internal trauma
K150	M	38	R	Classical medial condyle	Adult	Operation removal of loose body from supra patellar pouch	Relief of locking symptoms	Six years history Very large lesion medial condyle. Loose body probably separated four years previously
			L	Classical medial condyle				
K151	M	24	R	Classical medial condyle	Adult	Operation replacement of free loose body: internal fixation	Healed at exploration healed radiologically	Large defect 2 x1 in medial condyle. Loose body free in suprapatellar pouch Better result of repair obtained than thought possible

TABLE III (*continued*)

Case No	Sex	Age	R or L	Site	Variety	Treatment	Result	Notes
K152	M	18	L	Classical medial condyle	?Adult	Observation		Back knee premature closure anterior aspect upper tibial epiphysis. Dysostotic constitution. Multiple deformities of undetermined origin Osteochondritis dissecans lesion probably mechanical
K153	M	16	L	Patella	Juvenile	Operation removal of loose body smoothing of crater	Relief of locking symptoms	Dysostotic constitution Loose body located under anterior horn lateral meniscus. Lesion medial aspect midline of patella but not marginal
K154	F	11	R	Classical medial condyle	Juvenile	Operation drilling	Healed clinically and radiologically	Followed for one year as anomaly of ossification but became juvenile variety osteochondritis dissecans
K155	M	14	L	Lateral femoral condyle	L—Juvenile	L—Operation drilling	Healed clinically and radiologically	Example of dysostotic constitution. Exceptionally small stature at age 14 Cartilage unfractured in unusual tibial lesion on R? due meniscus tear
			R	Lateral tibial condyle	R—?Adult	R—Operation drilling from side excision of torn lateral meniscus	Healed clinically and radiologically	
K156	M	17	L	Classical medial condyle	Juvenile	Operation drilling and internal fixation with three nails	Healed at exploration healed radiologically	Two years history Large loose body in posterior compartment
K157	M	12	R	Classical medial condyle	Juvenile	R—Operation drilled from medial side	Healed radiologically	Dysostotic constitution under sized for age
			L	Classical medial condyle		L—Operation drilled from medial side	Not known yet	
K158	M	20	R	Classical medial condyle	?Adult	Operation drilling and internal fixation	Healed at exploration	Back-knee deformity Weight 18 st. at age 20

TABLE III (*continued*)

Case No	*Sex*	*Age*	*R or L*	*Site*	*Variety*	*Treatment*	*Result*	*Notes*
K159	M	12	R	Classical medial condyle	Juvenile	R—Operation drilling	Not known yet	Dysostotic constitution very small for 12. Mother's height 4' 9"
			R	Lateral femoral condyle		R—Operation drilling	Healed radiologically	
			R	Lateral tibial condyle		R—Operation tibial condyle drilled from front	Not known yet	
			L	Lateral tibial condyle		L—Observation		
K160	M	19	R	Lateral aspect lateral condyle	?Adult	Operation crater smoothed	Relief of symptoms	Accident two years ago probably osteochondral fracture
K161	M	16	L	Centre lateral condyle	Adult	Operation removal of loose body	Relief of locking symptoms	Torn lateral meniscus removed five years previously- almost certainly related. Repair not justified
K162	M	14	R	Classical medial condyle	Juvenile	Operation drilling from medial side	Not known yet	Brother of K157 Dysostotic constitution. Anomaly of ossification left patella, traction epiphysitis left patella
K163	M	18	L	Classical medial condyle	Adult	Operation drilling	Healed radiologically	Secondary to mechanical upset from fractured tibia. Lesion affected articular cartilage only Radiological appearances of cysts similar to that seen in capitellum
K164	M	16	R	Classical medial condyle	Juvenile	Operation drilling and internal fixation with two nails	Not known yet	Massive lesion $2\frac{1}{4}$"x$1\frac{1}{4}$
K165	F	74	R	Classical medial condyle	Adult	R—operation removal of loose body	R—Relief of locking symptoms	Contrast lesion medial eminence tibial spine result of degenerative change.
			L	Classical medial condyle		L—Observation		

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CHAPTER 10

METATARSO-PHALANGEAL JOINT (FREIBERG'S INFRACTION KÖHLER'S SECOND DISEASE)

THIS juvenile osteochondrosis, in the form known as Freiberg's infraction, has received little attention in the orthopaedic literature in the English language since the original description There is no more than passing reference in current textbooks and those who seek the details of treatment will find monographs on the foot hardly less unhelpful. It is nevertheless a common source of pain in the forefoot in the adolescent girl and sometimes of permanent disability in later life Table IV the record of eighty consecutive cases encountered in the course of six years, provides an answer to any critic who thinks the condition is rare or too trivial to warrant attention.

CORRELATION OF CLINICAL AND RADIOLOGICAL FEATURES

Stage I—At this the earliest stage the diagnosis is essentially a clinical diagnosis unsupported by definite radiological features. The patient usually a girl aged between ten and fifteen complains of pain in the foot of short *duration say three to six weeks The pain is present on walking and* is localised to a metatarsal head usually the second but sometimes the third. On examination the foot may be of structurally weak type the second toe relatively long and the proximal phalanx the subject of a slight dorsiflexion deformity which is passively correctable There is tenderness accurately localised to the dorsum of the affected metatarsal head but there is neither ridge nor other palpable abnormality

Radiology—There are no definite radiological features The earliest sign as in Perthes disease, is an increase of joint space (Figs **10 1** and **10 2**) If the clinical diagnosis has already been made a slight increase of density of the subchondral bone and flattening of the head may be detected (Fig. **10, 3**)

Stage II - The basic features are the same but the symptoms have existed for a [illegible]er period and the signs more clearly defined

Radiology.—The stage is characterised by an increase in density of the subchondral bone and a flattening or squaring of the head (Fig. 10, 3)

Stage III.—At this stage the dorsiflexion deformity of the toe is no longer readily correctable and palpation reveals enlargement of the head and the presence of a ridge on the dorsum of the metatarsal (Fig. 10, 4)



Fig. 10, 1 Fig. 10, 2 Fig. 10, 3

Freiberg's Infraction Radiological Features

Figs. 10, 1 and 10, 2 Stage I Earliest radiological sign is a significant increase of joint space (C. S., female, aged 1_, MT77 Table IV) Fig. 10, 3 Two months later. The head is dead. Density of the epiphysis in easily detectable degree with fatigue fracture showing. These changes occurred while under immobilisation in plaster and are the reason for the operation described.

Radiology.—A zone of apparent rarefaction is visible deep to the dense subchondral bone. This is an actual space and the area from which cancellous tissue has been absorbed. On the proximal side of this rarefaction is a zone of sclerosis. In the antero-posterior projection the potential loose body may have sunk into the head leaving small projections of bone on either side (Fig 10, 17) In the lateral view the contour of the head will be lost on the dorsal as opposed to the plantar aspect

Stage IV — The diagnosis is unmistakable and is characterised by the marked enlargement of the metatarsal head and palpable ridge on the dorsum.

Clawing of the toe is evident. This deformity which is a constant feature of the condition, has been the subject of some speculation as to cause or effect It is explained, at least in the later stages by the pathological



FIG. 10, 4
Freiberg's Infraction: Clinical Features
At Stage III the swelling of the metatarsal head may be visible as well as palpable

anatomy the cartilage remains intact on the inferior aspect while absorption of underlying bone and consequent depression of the articular surface takes place on the superior aspect. The proximal phalanx becomes dorsiflexed because there is no alternative but to follow the changing contour of the bone with which it articulates.

Radiology —A loose body consisting of a large proportion of the articular surface will be seen to have separated and sunk into the metatarsal head. Smaller loose bodies from fracture of the bony projections on either side of the large fragment may be evident. In the lateral view the bony element of the loose body will be seen to have fractured on the plantar aspect with consequent loss of alignment.

Stage V —In the final or adult stage the symptoms vary and range between metatarsalgia or pressure of a shoe on the dorsiflexed toe to incidents of

mechanical origin due to gross incongruity of opposing joint surfaces or the momentary locking of a loose body In relation to the dorsiflexed toe it should be recorded that the rigidity of the deformity renders it vulnerable to injury In one instance, a hyperflexion strain produced a fracture of a dorsal exostosis In the series four adult patients attributed their disability to a minor industrial accident for which they sought compensation

A proportion of adult cases encountered for one reason or another but sometimes incidentally deny having suffered pain or other symptom previously

Radiology —This is the form in which the condition is most frequently encountered. It is not always recognised for what it is the end result of a pathological process which began in adolescence

In the antero-posterior view the head of the bone is broad flat and triangular sometimes even cup-shaped (Fig. 5, 4) The base of the phalanx is broadened but less distorted than the metatarsal head. The opposing surfaces are incongruous. The loose bodies, which may have been evident of earlier stages, are much reduced in size or may have disappeared The shaft of the metatarsal is characteristically thickened and dense (Fig. 5, 3)

In the lateral view the extreme plantar aspect of the articular surface is seen to have retained the normal contour The dorsal two-thirds or more is flat or concave. The proximal phalanx is dorsi-flexed and the opposing surfaces incongruous.

AGES AND STAGES

Table II (page 79) indicates the ages and stages at which the patients were encountered It will be seen that, with a few exceptions the cases at Stage I to Stage III when reparative measures are possible fall in the age group 10-15 It would be of interest and importance to know the rate of progress through the stages. This series failed to provide the answer Two cases at Stage I and already referred to were subjected to operation one at three weeks and the other at two weeks from the onset of symptoms. The fracture was present and the opposing surfaces sclerosed. What is not known is how long the interference with nutrition and even the fracture existed before the symptoms But two points are evident first, the condition advances rapidly in the initial stages and the opportunity for restoration of the anatomy may not exist for more than say three months and second the pathological anatomy is so much further advanced than the radiographs appear to indicate that, in general a case in which the radiological features are unmistakable should be regarded as at least Stage II and treated accordingly

INDICATIONS AND TREATMENT

Stage I.—Reference has been made to the means by which healing by rest, and possibly even spontaneously can occur in the particular anatomical circumstances of this form of juvenile osteochondrosis and osteochondritis dissecans lesion. It has been established beyond reasonable doubt that the condition can heal in the earliest stages by prolonged immobilisation but only at the cost as in cases which heal spontaneously of some permanent deformity of the head In these circumstances it is not unreasonable that the earliest stage before a definite radiological diagnosis is possible, should be treated idealistically and especially when absolute perfection is probably obtainable only at this stage In this respect it is perhaps unfortunate that an accurately fitting insole and metatarsal dome will relieve the symptoms but without necessarily influencing the progress of the disease

It can be argued that the justification for operation, or even immobilisation in plaster without radiological confirmation of the diagnosis is open to question. The writer does not subscribe to this view The surgeon should, on the clinical evidence presented, have the courage to recommend operation, and thereafter apply a walking cast for a period of twelve weeks in the knowledge that by such means the condition will heal without residual deformity

Stages II and III.—Deformity has occurred in varying degree but the cartilage on the plantar aspect of the lesion remains intact and flexible. Reduction is therefore possible by operative means and can be maintained by packing the resulting space with cancellous fragments. In determining whether the plantar articular cartilage is fractured or not that is to say whether such measures are possible, the most information is obtained from the oblique radiograph from which it will usually be possible to tell whether the loose body has separated In this regard the antero-posterior view is not of assistance.

Operation is followed by a period of twelve to sixteen weeks of immobilisation in a walking plaster cast.

Stages IV and V—The opportunity for restoration of the anatomy has passed. Treatment is symptomatic and palliative. The necessity for operation varies. Loose bodies and marginal osteophytes may require removal the base of the phalanx or the remnant of the head of the metatarsal excision

The appliance which gives the greatest measure of relief at all stages is the full length leather insole and metatarsal dome accurately fitted for position and height to the requirements of the individual case

OPERATIVE TREATMENT REPARATIVE MEASURES

The aim of operation is the establishment of a new blood supply to the epiphysis across the epiphyseal plate The addition of cancellous chips may be required to replace bone tissue which has been absorbed and to preserve reduction so that the original contour of the head is restored

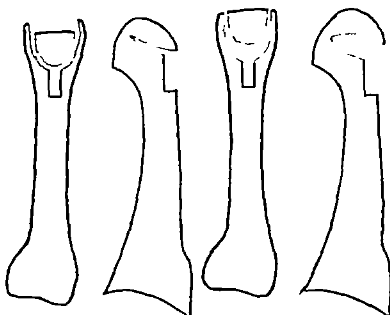


Fig. 10 5 Fig 10, 6 Fig. 10 7 Fig. 10, 8

Technique of Operation in Freiberg's Infraction: Diagrammatic Representation

Figs. 10, 5 and 10, 6 Access to the posterior aspect of the potential loose body and to the sclerotic bone in the neck of the metatarsal is obtained by cutting a slot half an inch long by three-sixteenths wide in the dorsum of the shaft. Figs. 10 7 and 10 8 When fibrous tissue has been excised and sclerotic bone and epiphyseal plate perforated, the deformity is reduced and the resulting space packed with cancellous bone chips.

An incision two inches long is made over the dorsum of the metatarsal head, extending a short distance on to the proximal phalanx. The tendon is identified and retracted to the lateral side The capsule synovial membrane and periosteum are divided in the mid-line and dissected off the head and neck to a degree sufficient only to expose the fissure and determine the extent of the lesion Access to the posterior aspect of the fragment and to the sclerotic bone in the neck of the metatarsal is obtained by cutting a slot half an inch long by three-sixteenths of an inch wide in the dorsum of the shaft (Figs 10, 5 and 10, 6 10, 9 and 10, 10) The next step is determined by the stage of the lesion.

Stages I and II.—In neither is there a serious problem of deformity due to absorption of bone. It is a matter of re-establishing a blood supply to the



FIG. 10, 9



FIG. 10, 10

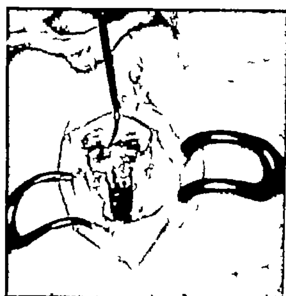


FIG. 10 11

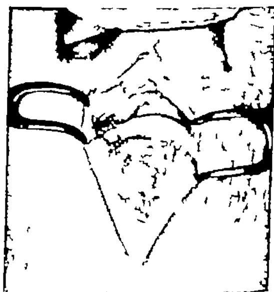


FIG. 10, 12

Treatment: Stages of Operation

FIG 10, 9 Head of metatarsal exposed to reveal the fracture. FIG. 10, 10 Slot to gain access has been cut. FIG. 10, 11 Main mass of the head levered distally to reduce the deformity FIG 10 12. Resulting space packed with cancellous chips.

bony element of the fragment by breaking down the barrier of sclerosis on both sides of the fissure This is done by excising fibrous tissue and roughening, with the point of a fine gouge the proximal aspect of the bony element of the fragment. The sclerotic zone on the proximal aspect of the fracture is treated in a similar manner and the epiphyseal plate subjected to multiple penetrations with the point of the gouge (Figs **10,** 13 to **10,** 16)

Stage III—At this, the latest stage at which reparative measures are likely to be effective, deformity of the head is present but the potential loose body still attached by an intact isthmus of cartilage The degree of collapse into the head is determined and the fragment then gently levered distally on the *hinge until the deformity is corrected All the fibrous tissue is excised from the* opposing margins of the fissure The bony element of the fragment and the sclerotic base of the crater are drilled or gouged as in Stages I and II The space which exists when reduction is complete is packed with small autogenous cancellous chips, the quantity used being determined by the alignment of the cartilaginous element to the medial and lateral margins of the articular surface (Figs. **10,** 7 and **10,** 8 **10,** 11 and **10,** 12 **10,** 17 and **10,** 18 **10,** 19 to **10,** 22) In this regard it should be noted that there is a tendency for displacement to recur In two cases in this series it was found that the reduction as a result of compression of the supporting cancellous chips was not fully maintained It is advisable therefore to over rather than under correct, in the knowledge that some compression of the cancellous chips will occur It is important however that the cancellous chips are not packed so closely that they fail to gain a blood supply The tourniquet is then released and any bleeding points secured. The capsule and periosteum are closed with fine interrupted catgut stitches

After-treatment.—At the termination of operation a compression bandage is applied in the terminal layers of which are incorporated a layer of plaster to keep the foot at rest In ten to fourteen days when the stitches are removed, the bandage is replaced by a skin-tight walking plaster cast which incorporates the second and third toes but leaves the big and remaining toes exposed. The cast is retained for a total of twelve weeks when radiographs to determine the progress are secured. The criterion of healing is the disappearance of sclerosis and especially in that portion of the fragment which underlies the articular cartilage and which is usually exceptionally dense If progress is judged to be satisfactory a gradual return to weight-bearing is permitted using a lacing shoe with a leather insole and sponge rubber metatarsal dome



FIG. 10, 13

FIG. 10, 14



FIG. 10, 15

FIG. 10, 16

Result of Operative *Treatment: Stage II*

FIG. 10, 13 and 10, 14 Before operation. Note sclerosis of subchondral bone fracture with absorption of cancellous tissue sclerosis on the proximal aspect of the fracture and open epiphysis. FIGS. 10, 15 and 10, 16. After operation (nine months). Lesion has healed Epiphysis has closed. (I T female aged 13 MT2., Table IV.)

OPERATIVE TREATMENT PALLIATIVE MEASURES

Stage IV—Removal of the central loose body the spikes of bone on each side of the head and the exostoses on the dorsum of the neck will usually produce alleviation of symptoms when combined with the use of an insole and metatarsal dome

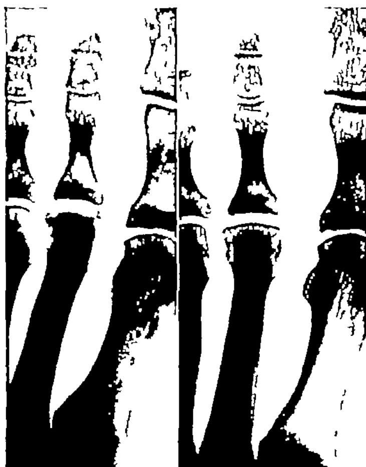


Fig 10, 17 Fig. 10, 18

Result of Operative Treatment: Stage III

Fig. 10, 17 *Before operation Note the considerable* deformity in the antero-posterior view with bony projections on either side of potential loose body Fig 10 18 After operation Contour and trabeculation of the head has been restored. Epiphysis has closed.

Stage V—Three procedures are in common use singly or in combination (1) removal of loose bodies combined with excision of exostoses from the dorsum of the metatarsal neck (2) excision of base of phalanx and (3) excision of metatarsal head

The method selected will depend on the nature and origin of the symptoms In general the less radical the operation the better the end result.

FIG. 10, 19



FIG. 10, 20

FIG. 10, 21

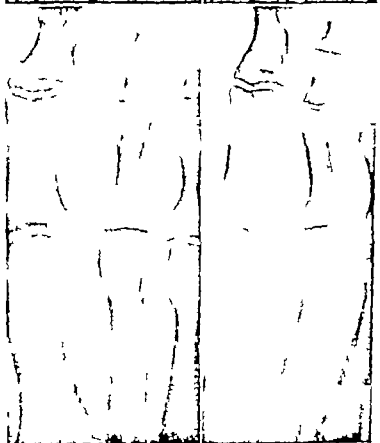


FIG. 10, 2–

Result of Operative Treatment: Stage IV

FIG. 10, 19 Before operation Antero-posterior showing fractured ears on either side of head and dense central fragment sunk beneath the surface FIG. 10 20 Lateral showing flattening and deformity FIG. 10, 21 After operation. Antero-posterior shows head to have healed with slight deformity but no reduction of joint space. FIG. 10, 2– Lateral shows healing with slight deformity in the form of flattening. This is the most advanced case to which the technique of reduction and bone grafting was applied. It was attempted only when it was found that reduction was possible (C S., female aged 15 MT59 Table IV)

In particular the head of the metatarsal should if possible be preserved It has been shown that the plantar portion of the head remains intact If the metatarsal shaft is thickened as it invariably is it can only be in response to the stimulus of weight bearing Excision of the base of the proximal phalanx of a functionless toe is an innocuous measure Excision of the head of a weight-bearing metatarsal is not

TREATMENT AND RESULTS

Four cases at Stage I were treated by immobilisation in plaster Three healed without deformity One the most advanced of the four healed with flattening of the head Four cases were subjected to operation and healed without deformity Seven cases at Stage II subjected to operation healed without deformity Nine cases at Stage III were treated by operative reduction and bone grafting. All healed with minimal or no deformity

An attempt was made early in the series, to restore the anatomy at Stage IV when the loose body had separated. The object was not attained and little, if anything, was gained from operation A second case treated on an idealistic level when reduction was achieved healed with the result recorded in Figs. **10, 19** to **10, 22**

It should not be concluded that these results exhaust the potentialities for reparative measures in a series of this size There were other patients who were seen before the method of reduction and bone grafting was evolved were wrongly treated conservatively or who received no treatment at a stage when in the light of later experience, operation was clearly indicated

At later stages, when only palliative measures were possible patients were variously treated by removal of the loose body and reshaping of the head excision of the base of the phalanx or by excision of the remainder of the head of the metatarsal

In all a full-length insole and metatarsal dome was used either as a temporary measure in the late after treatment of cases in which the head was restored or as a permanent measure in adults treated conservatively or by palliative operation

TABLE IV

Sex	Age	R or L	2nd or 3rd	Stage	Treatment	Result	Notes
F	39	R	3rd	V	Foot support	Relieved	Associated with March fracture of 2nd on opposite side
F	16	R	3rd	IV	Foot support	Unknown	
M	25	R	2nd	V	Operation removal of loose body trimming of metatarsal head	Relieved	
[illegible]	28	R	2nd	V	Low heel shoe Metatarsal bar	Relieved	History of pain from age 14
	17	L	3rd	V	Operation removal of potential loose body	Relieved	
	13	L	2nd	II	Foot support	Outcome unknown	Could have been repaired by operation
	12	R	2nd	I	Immobilisation in plaster	Healed with some deformity	Probably better result by operation
	16	L	2nd	IV	Operation loose body removed and head trimmed	Relieved	
	25	R	3rd	V	R—Operation base of phalanx excised and head trimmed	Relieved	
		L	3rd	V	L—Insole and dome		
	15	L	3rd	III	Operation removal of potential loose body and trimming of head	Relieved	Could have been repaired by operation

TABLE IV (*continued*)

Age	R or L	2nd or 3rd	Stage	Treatment	Result	Notes
18	R	2nd	V	Operation loose body removed head of metatarsal trimmed	Apparent relief of symptoms	
21	R	2nd	V	Operation removal of head of metatarsal	Unknown	
19	R	2nd	V	Operation loose body removed head trimmed	Apparent relief of symptoms	
17	R	2nd	III	Immobilisation by plaster cast	Unhealed in last radiograph	Could have been repaired by operation
50	R	2nd	V	Insole and dome	Relief of symptoms	
15	R	3rd	IV	Insole and dome	Unknown	
15	R	2nd	IV	Operation base of phalanx and head of metatarsal excised	Apparent relief of symptoms	
18	R	2nd	IV	Metatarsal bar	Unknown	
53	L	2nd	V	Insole and dome	Apparent relief of symptoms	
15	L	2nd	III	Operation potential loose body removed and head trimmed	Unknown	Could have been restored by conservative surgery
18	L	2nd	V	Originally conservative insole and dome Later operation trimming and removal of loose body	Relieved	

TABLE IV (*continued*)

Case No	*Sex*	*Age*	*R or L*	*2nd or 3rd*	*Stage*	*Treatment*	*Result*	*Notes*
MT22	F	13	R	2nd	II	Operation drilling	Normal	First attempt conservative surgery
		14	L	2nd	I	Operation drilling	Normal	
MT23	F	18	R	2nd	V	Insole and dome	Apparent relief	
				3rd	V			
MT24	F	15	R	2nd	II	Immobilisation in plaster cast	Healed with deformity	Could have been restored by conservative surgery
MT25	F	12	L	2nd	III	Operation reduction and bone grafting	Healed without deformity	
MT26	F	13	R	3rd	IV	Operation reduction and bone grafting	Healed but imperfect	
MT27	F	15	R	2nd	IV	Insole and dome	Healed with deformity	Opportunity occurred for treatment elsewhere at age 13 Could have been restored by conservative surgery
MT28	F	14	L	2nd	IV	Attempt made to reduce and graft but too far advanced loose body and exostoses removed, insole and dome	Symptomless three years later	
MT29	M	22	R	2nd	V	Immobilisation in plaster cast elsewhere at age 16	Gross deformity	Could probably have been restored at age 16 by conservative surgery
MT30	F	11	L	3rd	III	Reduction and bone grafting	Healed without deformity	
MT31	F	33	L	2nd	V	Insole and dome	Relieved	
MT32	M	15	R	2nd	I	Plaster immobilisation	Healed with minimal deformity	

TABLE IV (*continued*)

Case No	*Sex*	*Age*	*R or L*	*2nd or 3rd*	*Stage*	*Treatment*	*Result*	*Notes*
MT22	F	13	R	2nd	II	Operation drilling	Normal	First attempt conservative surgery
		14	L	2nd	I	Operation drilling	Normal	
MT23	F	18	R	2nd	V	Insole and dome	Apparent relief	
				3rd	V			
MT24	F	15	R	2nd	II	Immobilisation in plaster cast	Healed with deformity	Could have been restored by conservative surgery
MT25	F	12	L	2nd	III	Operation reduction and bone grafting	Healed without deformity	
MT26	F	13	R	3rd	IV	Operation reduction and bone grafting	Healed but imperfect	
MT27	F	15	R	2nd	IV	Insole and dome	Healed with deformity	Opportunity occurred for treatment elsewhere at age 13 Could have been restored by conservative surgery
MT28	F	14	L	2nd	IV	Attempt made to reduce and graft but too far advanced loose body and exostoses removed insole and dome	Symptomless three years later	
MT29	M	22	R	2nd	V	Immobilisation in plaster cast elsewhere at age 16	Gross deformity	Could probably have been restored at age 16 by conservative surgery
MT30	F	11	L	3rd	III	Reduction and bone grafting	Healed without deformity	
MT31	F	33	L	2nd	V	Insole and dome	Relieved	
MT32	M	15	R	2nd	I	Plaster immobilisation	Healed with minimal deformity	

TABLE IV (*continued*)

Case No	Sex	Age	R or L	2nd or 3rd	Stage	Treatment	Result	Notes
MT33	F	13	L	2nd	V	None	Healed with deformity	Opportunity at 11 could hav been restored by operation
MT34	F	15	R	2nd	III	Operation reduction and bone grafting	Healed clinically-radiologically indistinguishable from normal	
MT35	F	18	R	3rd	V	None		
MT36	F	18	L	2nd	III	Operation reduction and bone grafting	Healed but not absolutely perfect	
MT37	F	14	L	2nd	III	Operation reduction and bone grafting	Healed clinically and radiologically	Slow to heal but reduction maintained. Complete restori tion of plantar flexion at age 16
MT38	M	22	L	2nd	V	Insole and dome	Apparent relief	
MT39	F	42	L	2nd	V	Insole and dome	Apparent relief	Operation elsewhere four year previously—probable remov of loose body
MT40	F	48	R	2nd	V	Insoles and domes	Apparent relief of symptoms	
			L	2nd	V			
MT41	F	13	R	2nd	III	Operation reduction and bone grafting	Healed with slight flattening of head	
MT42	F	14	R	2nd	III	Operation reduction and bone grafting	Radiograph virtually indistinguishable from normal eighteen months later	
MT43	M	54	L	2nd	V	Insole and dome	Relieved	
MT44	M	[illegible]6	L	2nd	V	Insole and dom	Relieved	
MT45	F	14	L	2nd	II	Operation reduction and bone grafting	Healed without deformity	Nine weeks history This patient suffered from Perthes disease at age of 6

TABLE IV (*continued*)

Case No	*Sex*	*Age*	*R or L*	*2nd or 3rd*	*Stage*	*Treatment*	*Result*	*Notes*
MT46	M	14	R	2nd	II	Operation reduction and bone grafting	Healed without deformity	Fourteen weeks history Symptomless two years later
MT47	F	45	L	2nd	V	Insole and dome	Symptoms relieved	Operation twenty-seven years ago
MT48	F	48	L	2nd	V	Insole and dome	Symptoms relieved	Complained at age 14 but undiagnosed
MT49	F	52	R	2nd	V	None		No symptoms Healed spontaneously without gross deformity
MT50	M	22	L	2nd	V	None	Pain at athletics only Healed with relatively little deformity	
MT51	F	10	L	3rd	II	Operation reduction and bone grafting	Healed without deformity	Radiograph virtually indistinguishable from normal eighteen months later
MT52	F	43	L	2nd	V	Insole and dome	Symptoms relieved	
MT53	F	38	L	2nd	V	Insole and dome	Present symptoms relieved	No previous symptoms
MT54	F	59	R	2nd	V	Insole and dome	Symptoms relieved	Weak foot, short 1st metatarsal, hallux valgus
MT55	F	17	L	2nd	V	Insole and dome	Symptoms not relieved	Three years history
MT56	F	44	R	2nd	V	Insole and dome	Relieved	
MT57	F	16	L	3rd	I	Plaster immobilisation		Six weeks history
MT58	F	43	R	2nd	V	Insole and dome	Relieved	
MT59	F	15	R	2nd	IV	Operation reduction and bone grafting	Healed clinically-healed radiologically with slight deformity	Symptoms nine months before reaching Stage IV
MT60	F	40	R	2nd	V	None		Incidental finding following recent fracture of 5th metatarsal

TABLE IV (*continued*)

Case No	Sex	Age	R or L	2nd or 3rd	Stage	Treatment	Result	Notes
MT61	F	22	L	3rd	III	Operation removal of exostoses from meta tarsal head	Relief of symptoms	Probably later stage than recorded Restoration of head not possible
MT62	M	32	L	3rd	V	None		Incidental finding following fracture
MT63	F	33	L	2nd & 3rd	V	Insole and dome	Relieved	Pain in the foot since age 14
MT64	F	12	R	3rd	II	Operation drilling	Healed clinically and radiologically six months later	Two months history Long 2nd toe
MT65	F	14	R	2nd	IV	Operation removal of exostosis, drilling	Healed with some deformity of head	One year history
MT66	F	16	L	2nd	V	Operation removal of loose body· excision of base of phalanx	Immediate symptoms relieved	
MT67	M	16	L	2nd	II	No treat ment accepted		Did not report for admission to hospital
MT68	F	41	L	3rd	V	Insole and dome		Gross deformity with central and lateral loose bodies; will probably require operation
MT69	F	16	L	2nd	III	Operation reduction and bone grafting	Healed clinically· radiologically complete restoration of anatomy	
MT70	F	13	R	2nd	I	Operation drilling	Complete restoration of metatarsal head	Two months history of pain
MT71	F	12	R	2nd	II	Operation drilling	Healed radiologically	Weight bearing resumed three months from operation
MT72	F	67	L	2nd	V	None		Incidental finding
MT73	F	12	R	2nd	II	Operation reduction and bone grafting	Complete restoration of anatomy	Four months history· marked thickening of metatarsal shaft

TABLE IV (*continued*)

Case No	*Sex*	*Age*	*R or L*	*2nd or 3rd*	*Stage*	*Treatment*	*Result*	*Notes*
MT74	F	12	R	2nd	I	Operation drilling	Complete restoration of anatomy	Dysostotic constitution. Mother's height 4' 10" patient's height 4' 11" aged 12
MT75	F	52	L	2nd	V	None	No symptoms	Healed spontaneously at Stage I II with some deformity
MT76	M	12	L	2nd	II	Operation drilling: supplementary bone required	Healed radiologically with minimal deformity	This boy at age 12 is 5' 8" and weighs 11 st. Three months' history
MT77	F	17	R	2nd	V	Operation trimming of metatarsal head	Symptoms relieved	This is an example of a case which had healed spontaneously at Stage II. Operation undertaken to remove exostoses from metatarsal head
MT78	F	12	R	2nd	I	Immobilisation in plaster	Not known yet	No radiological change but increase of joint space
MT79	F	41	R	2nd	V	None		Incidental finding. This patient is an example of a case which healed spontaneously at Stage II and in which the final deformity of the head was not gross
MT80	F	9	L	2nd	I	Operation drilling	Complete restoration of anatomy	At operation whole epiphysis demonstrated to be ischaemic and with fracture at usual site

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CHAPTER 11

ELBOW JOINT

CLINICAL **features.**—It will be evident from the wide range of ages recorded in Table V that a distinction must be drawn in osteochondritis dissecans between the elbow a non weight bearing joint, and the other joints affected. In the elbow joint the lesion may remain silent for years Many of the cases encountered at twenty five probably occurred at fifteen An occa sional clinical note reveals the pathological changes to have existed in some instances, for decades.

The table indicates that patients presenting are predominantly male and that the disease has a striking predilection for the right side If the role of injury is difficult to assess, the evidence implicating trauma in some form is overwhelming. In this regard the liability to develop the lesion was noted to be increased in some occupations If a professional boxer for example is liable to sustain a Bennett s fracture of the thumb he is also liable for similar reasons to develop osteochondritis dissecans of the elbow

The clinical features of the early cases are variable The onset is insidi ous. The complaint may be of no more than dull pain or ache in the joint accompanied by some stiffness The first symptom is often that produced by a loose body Sudden spontaneous locking followed by pain and effusion is almost pathognomonic of osteochondritis dissecans

The most constant finding on examination is limitation of extension sometimes also of flexion, and a palpable, sometimes visible, enlargement of the head of the radius Hypertrophy of the head is such an outstanding feature that at operation the capsule may be found to be so tightly stretched over it that care must be taken in entering the joint not to damage the covering articular cartilage

It should be recognised that the nature of the pathological anatomy is such that locking incidents are possible in the absence of a free loose body discernible in a radiograph Reference has been made to the size of the head of the radius and to the proximity of the capitellum A hinged flap of articular cartilage may doubled upon itself become wedged momentarily between the moving surfaces and produce the incident.

Radiological features.—The appearance of a fragment of subchondral bone surrounded by a zone of translucency enclosed by a zone of sclerosis which is typical of osteochondritis dissecans in the knee or ankle is not the

usual lesion seen in the elbow The reason for this is evident from the pathological anatomy which has been described. The bony element of the separating loose body is seldom of any considerable dimensions. The lesion although it may involve two-thirds of the articular surface of the capitellum, consists of cartilage separated from bone, or through the surface layers of the bone The radiological features may therefore be nothing more than those produced by the reaction of bone to the loss of the normal cartilaginous covering. These consist, in the antero-posterior view of patchy ill-defined rarefaction or small translucent cyst-like areas surrounded by patchy sclerosis. Occasionally there is a sizeable fragment of bone as in osteochondritis dissecans at other sites. When the condition affects the head of the radius the lesion is more sharply defined and a defect may be seen in the convex rim. In the later stages following the separation and hypertrophy of loose bodies and the development of secondary osteoarthritis it may be difficult to determine the site of the original lesion.

One, two three or more loose bodies may be present. The common sites in which they are found are the coronoid fossa, the olecranon fossa, the space between neck of radius and ulna and in the region of the head of the radius. Sometimes one loose body may be in one site and one in another

Differential diagnosis.—The condition with which the diagnosis is most readily confused is tuberculosis. The error occurs when the radiograph takes the unusual form of a single large rarefied area which simulates a destructive lesion in the capitellum. There were two such cases in the Roberts and Hughes (1950) series one in this series. An osteoarticular focus of tuberculosis might reasonably be expected to be accompanied by synovial reaction. The absence of swelling may provide the clue to the correct pathology

INDICATIONS AND TREATMENT

It will be seen from the Table that in general treatment is not sought until hypertrophy of the separated loose bodies has reached a degree which produces locking incidents or actual mechanical interference with movement. The opportunities for conservative surgery if such measures were necessary or desirable, would be limited (Figs. **11**, 1 and **11**, 2)

Roberts and Hughes state that a review of the literature indicates that the general opinion is against early operative intervention They are of the opinion that the fate of an incompletely detached fragment of articular cartilage or hinged loose body cannot be forecast and when the site is exposed at operation in an early case there exists the temptation to remove partially detached fragments as well as loose bodies. It is suggested that if

these fragments were left in place they might survive and help to reconstitute a better articular surface for the capitellum They conclude that operation should not be undertaken

The experience of this series would agree that there is no general indication for operative intervention in youth The recommendation is based on the etiological factor of the proximity of the head of the radius to the capitellum and that the sequence of events cannot be influenced without excision of the head It is unlikely from what is known of the pathology of the lesion that hinged osteoarticular fragments or tags of articular cartilage become re-attached

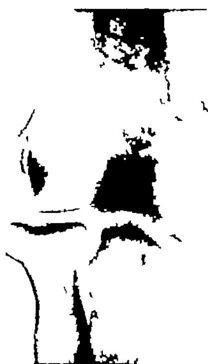


Fig 11 1



Fig 11 2

Old-standing lesion in capitellum with loose body in the coronoid fossa In the majority of cases treatment consists of removal of loose bodies to relieve symptoms of locking. Little opportunity exists for conservative surgery

spontaneously It is possible, by methods which have been described in relation to the knee to secure re-attachment by re-establishing a blood supply to the bone element of a potential osteoarticular loose body and re-attachment of tags of articular cartilage by drilling the bone surface from which they came. But it is essential that such measures be followed by a considerable period of complete rest. The elbow joint reacts unfavourably in terms of return of movement, to prolonged immobilisation in the final result the capitellum is still subject to trauma from the radial head Moreover it has been pointed out that the common radiological finding of a cyst-like appearance is no more than indicative of detachment of articular cartilage Such

cases seldom appear to develop loose bodies. In all these circumstances the attempted repair of the site or the operative removal of tags of cartilage as a prophylactic measure seem without point.

If no indications for exploration exist, there are frequently specific indications for an operation the object of which can be defined

1 **Relief of locking.**—Table V indicates that the removal of loose bodies was the commonest reason for operation In most cases the loose body or bodies have been free within the joint for some time before increase of size or alteration of position produces incidents which compel the patient to seek advice In such circumstances the loss of movement at the limits of flexion or extension or both but which may not have been noticed by the patient is likely to be the result of the insidious development of osteoarthritis rather than the presence of the loose body *per se* Operation on such a joint will relieve the locking but only in exceptional circumstances will a noticeable increase of movement result.

In view of the size and, by implication the time which has elapsed since separation it is seldom necessary or desirable to take special steps in addition to the one or more small non-destructive incisions required to remove the loose bodies to explore the site from which they arose In the unusual conditions of a large bone element in the lesion the radiograph might indicate that a second loose body was due to separate In these circumstances exploration of the crater would be justifiable

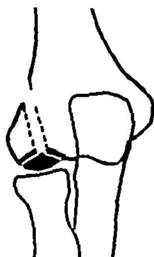


FIG 11 3

Osteochondritis dissecans of capitellum. conservative surgery Diagrammatic representation of a possible method by which the crater from which a large osteo-articular fragment was separating could be prepared from above.

2. **Increase of movement.**—If the head of radius is much enlarged distorted, or in direct contact with the capitellum so that extension and/or supination and pronation is restricted, excision of the head may be indicated Increase of movement from such measures is more likely in the early case than in one in which wear and tear changes have advanced to involve every compartment of the joint.

Excision of the head of radius provides wide access to the lesion in the capitellum The opportunity is taken to inspect and if necessary remove fragments likely to separate, or in exceptional circumstances to repair the articular surface In any event it is not unreasonable that exposed bone be drilled in the hope that the resultant fibrocartilage may fill the defect and improve the congruity of the articular surface

3 **Restore articular surface.**—The opportunity for conservative surgery he treatment of osteochondritis dissecans of the elbow joint, as indicated Table V is limited The very nature of the pathology which entails rgement of head of radius and proximity to capitellum denies direct ss to the lesion If the head is excised access is excellent but in this it idealistic measures could rarely be justified. There are undoubtedly umstances however in which the lesion is so extensive that restoration of articular surface is desirable even when combined with excision of the d of radius Only one such case was encountered in the series. The result, erms of restoration of movement was disappointing Repair was effected g the methods described in Chapter 9 without excision of the head of us. It became evident later that an error of judgment occurred in re- ing the latter structure and excision may still be necessary

A decision as to what should be done must depend on the nature and nt of the lesion No difficulty will be encountered if the head of radius been excised The mode of access by which the base of the crater and e of an osteoarticular fragment can be prepared through a drill hole from ve in circumstances in which excision of the head of radius is considered ecessary is shown in Fig. 11, 3 (Smillie 1957)

TABLE V

Case No	Sex	Age	R or L	Site	Treatment	Result	Notes
E1	M	53	R	Capitellum	Operation loose bodies removed	Relief of locking	Loose bodies in coronoid and olecranon fossae Gross osteoarthritis
E2	M	22	R	Capitellum	Operation loose body removed	Relief of locking	Loose body between head of radius and coronoid process
E3	M	28	R	Capitellum	Operation loose body removed. Operation excision of head of radius	Relief of locking and increase of extension	Two operations. Loose body between neck of radius and ulna
E4	M	26	R	Capitellum	Operation loose bodies removed	Relief of locking	One loose body in olecranon fossa one behind head of radius
E5	M	24	R	Capitellum	Operation loose bodies removed	Relief of locking	
E6	M	21	L	Capitellum	Operation loose bodies removed	Relief of locking	One loose body in olecranon fossa one behind head of radius
E7	M	42	R	Capitellum	Operation loose body removed	Relief of locking	Loose body behind head of radius
E8	M	25	R	Capitellum	Operation two loose bodies removed	Relief of locking	Both loose bodies in coronoid fossa
E9	M	48	R	Capitellum	Operation loose body removed	Relief of locking increase of extension	Large loose body in olecranon fossa
E10	F	22	L	Capitellum	Operation two loose bodies removed	Relief of locking	Fall playing badminton three years previously query fracture. Both loose bodies in region head of radius
E11	M	34	R	Capitellum	Operation two loose bodies removed	Relief of locking	Both loose bodies in coronoid fossa
E12	M	25	R	Capitellum	Operation two loose bodies removed	Relief of locking	One loose body in coronoid fossa other on lateral aspect head of radius
E13	M	16	L	Capitellum	Operation loose body removed	Relief of locking	Loose body in coronoid fossa
E14	F	36	R	Head of radius	Operation excision of head of radius loose body removed	Increase of extension	Fall two years previously query fracture head of radius

TABLE V (*continued*)

Case No	*Sex*	*Age*	*R or L*	*Site*	*Treatment*	*Result*	*Notes*
E15	M	33	R	Capitellum	Operation loose body removed	Relief of locking; increased flexion	Loose body in coronoid fossa
E16	M	37	L	Capitellum	Operation loose body removed	Relief of locking	Gross osteoarthritis
E17	M	45	L	Capitellum	Operation loose bodies removed	Relief of locking	
E18	M	20	R	?Head of radius	Operation loose body removed excision of head of radius	Increase of extension	Origin probably head of radius where changes more advanced than capitellum
E19	M	20	R	Capitellum	Operation loose bodies removed	Relief of locking	
E20	M	28	L	Capitellum	L—Operation loose body removed		L—Loose body in coronoid fossa
		32	R	Capitellum	R—Operation loose body removed		R—Advanced osteoarthritis
E21	M	37	L	Capitellum	Operation loose body removed	Relief of locking return of movement	
E22	M	30	R	Capitellum	Operation two loose bodies removed		Changes in head of radius recorded as more advanced than capitellum. Further loose body between neck of radius and ulna five years later
E23	F	55	R	Capitellum	Operation loose bodies removed	Relief of locking	Loose bodies in coronoid fossa Gross osteoarthritis
E24	M	18	L	Head of radius	Operation loose body removed excision of head of radius	Increase of extension	Loose body in coronoid fossa. Probably congenital anomaly head of radius, or fracture in early youth
E25	M	19	R	Capitellum	Operation loose body removed	Relief of locking	Loose body between head of radius and ulna
E26	M	41	R	Capitellum	Operation loose body removed	Relief of locking	Late case superimposed osteo-arthritis
E27	M	16	R	Capitellum	Operation excision of head of radius, saucerisation of lesion	Increase of extension	This case was originally thought to be tuberculosis
E28	M	31	R	Capitellum	Operation loose bodies removed, excision of head of radius	Relief of locking, increase of movement	Gross osteoarthritis history dates from age 16

TABLE V (*continued*)

Case No	Sex	Age	R or L	Site	Treatment	Result	Notes
E29	M	52	L	Capitellum	Operation loose bodies removed	Relief of locking	Gross osteoarthritis
E30	M	35	R	Capitellum	Operation loose bodies removed	Relief of locking	
E31	M	40	R	Capitellum	Observation		Symptoms, apart from loss of movement, minimal
E32	M	47	R	Capitellum	Operation loose body removed	Relief of locking	Late case with osteoarthritic change
E33	M	17	L	Capitellum	Operation restoration of joint surface attempted	Doubtful if improvement achieved clinically or radiologically	Large bony element in separating fragment
E34	F	15	L	Capitellum	Operation excision of head of radius, saucerisation of lesion	Increase of extension	
E35	M	36	L	Capitellum	Operation loose body removed	Relief of locking	Seven years' history pain and locking
E36	M	34	L	Radius	Operation loose body removed	Relief of locking	History of injury possible osteochondral fracture
E37	M	20	L	Capitellum	L—Operation loose body removed	Relief of locking	Head of radius hypertrophied on both sides
			R	Capitellum	R—Operation loose body removed	Relief of locking	
E38	M	54	R	Capitellum	Operation loose bodies removed	Relief of locking	Marked hypertrophy head of radius gross osteoarthritis
E39	M	16	R	Capitellum	Operation excision of head of radius saucerisation of lesion		This is the case with a closed horizontal cleavage lesion in head of radius
E40	M	27	R	Capitellum	Operation loose bodies removed		Onset at age 16 head of radius hypertrophied
E41	M	54	R	Capitellum	R—Operation excision of head of radius	R—Range 60-160 three months after operation	
			L	Capitellum	L—Observation		
E4	M	43	R	Capitellum	Operation two large loose bodies removed	Relief of locking	Twenty years history of pain and limitation of movement. Now advanced osteoarthritis

TABLE V (*continued*)

Case No	*Sex*	*Age*	*R or L*	*Site*	*Treatment*	*Result*	*Notes*
E43	M	17	R	Capitellum	Operation excision of head of radius removal of potential loose bodies from lesion	Marked increase of extension *supination and* pronation	Injury ten years previously query anterior dislocation of *head of radius*
E44	F	14	R	Capit llum	Operation loose body removed Repair unneces sary	Full return of movement	Definite injury seven months previously Lesion also in head of radius apparently due impingement capitellum
E45	M	15	L	Capitellum	Operation excision of head of radius smoothing of site in capitellum	Relief of pain increase of movement	Known to have lesion capitel lum at age 13 Juvenile type arising from anomaly of ossification. Height 5 ft. at age 15 delayed maturity of ossification
E46	M	[illegible]6	R	Capitellum	Observation		Old fracture olecranon enlarge ment of head of radius

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Chapter 12

ANKLE JOINT

CLINICAL **features.**—The presenting symptoms are pain and swelling aggravated by weight-bearing and relieved by rest and elevation. Examination seldom reveals more than swelling and local tenderness

The complaint of instability or giving way is a common feature of the condition. In many cases the diagnosis is based on radiographs taken following a giving way incident in the clinical form of an acute sprain of the ankle

Example—This situation is illustrated in major degree by the case of J P female aged 72 (A14 Table VI) who sustained an injury to the ankle of the nature of a diastasis of the inferior tibio-fibular joint complicated by a fracture of the fibula The osteochondritis dissecans lesion on the supra medial aspect of the talus was an incidental finding in the fracture radiograph but on questioning the patient later the major injury almost certainly occurred as a result of a giving way incident produced by the dissecans lesion.

RADIOGRAPHY

Standard antero-posterior and lateral radiographs do not always reveal the lesion Oblique projections are often necessary not only to reveal but to demonstrate the extent of the pathology Multiple layer single-exposure tomography should be used prior to operation if the site cannot be detected in the normal lateral view or if any doubt exists regarding the exact location in the antero-posterior plane.

Osteochondritis dissecans is much less common in the ankle than in the knee the possibility tends to be forgotten It should be recorded that a single negative radiographic examination as in the knee joint, does not eliminate the diagnosis Unfortunately patients with recurrent sprains seldom receive a second radiographic examination the diagnosis is thought to be established But recurrent sprains are a symptom not a diagnosis The cause of the giving way incidents if it is osteochondritis dissecans, can be established only by repeated radiographic examination.

INDICATIONS FOR TREATMENT

Treatment is governed by the circumstances of the case The age sex occupation and severity determine the advice proffered In general it can be anticipated that the condition will progress to a painful arthritis which in extreme form may necessitate an arthrodesis (A13) Thus the younger the patient the stronger the inclination towards reparative surgery In the series under consideration the patients in the highest age groups subjected with success to conservative surgery were a male aged 56 by occupation a physical training instructor (A5) and a female aged 45 by occupation a school teacher (A9) In both instances treatment was determined by the decision of the patient that the occupation followed would require to be abandoned unless the ankle could be cured

It has been stated that the presenting symptom in lesions of the talus is often, in the early stages nothing more than a sprained ankle It may not be readily acceptable to a youthful patient that the cause of his sprain is a condition meriting operative interference followed by prolonged immobilisation in plaster Nor has sufficient evidence of the long term outcome of operation been available to force the issue It is for this reason that some cases which should have been subjected to operation had in fact to be treated expectantly until such time as idealistic measures had no longer the same chance of success.

BACKGROUND TO CONSERVATIVE SURGERY

In the original case in which reparative surgery was attempted the lesion was located on the medial aspect of the talus An antero-medial incision was made and gave good exposure of the antero-medial aspect of the bone but no amount of plantar flexion would bring the affected area into view The decision had therefore to be made whether to take no further action and close the wound or employ more radical measures The patient had been kept under observation for many months with symptoms of progressive severity a radical exposure was justifiable A screw was inserted in the medial malleolus prior to osteotomy after the manner employed in the coracoid process in the course of exposure of the shoulder joint It has been used without modification on a further five cases with satisfaction in regard to access rapidity of healing and result (Figs **12**, 1 and **12**, 2) It has an additional advantage in providing access to cancellous tissue if supplementary bone is required to raise the articular cartilage of the lesion to the normal level There is no evidence in the limited experience available that the osteoplastic exposure to be described is productive of disability *The method is not origi*

nal It appears to have been described first by König and Schafer (1929) and used with modifications by Ray and Coughlin (1947)

In the two cases in which reparative measures have been applied on the lateral side the osteoplastic procedure to be described has been employed (*Figs* **12**, *3 and* **12**, *4*) *It is non-destructive and has not produced a disability*

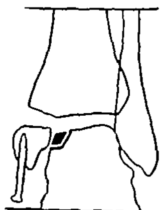


FIG. 12, 1

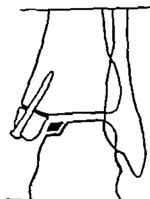


FIG. 12, 2

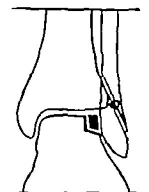


FIG. 12, 3

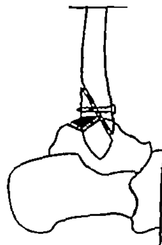


FIG. 12, 4

Operative Approach to the Talus
Diagrammatic representation of osteoplastic exposure of supramedial aspect (Figs. 12, 1 and 12, 2), and supralateral aspect (Figs. 12, 3 and 12, 4)

It provides less good exposure than that obtained on the medial side and time may show that the more radical and apparently more destructive horizontal osteotomy of the fibula described by Gatellier (1931) may be necessary

MEDIAL APPROACH

A vertical incision say three inches (7 5 cm) long is made over the anterior margin of the medial malleolus an level of th oint

located. This is done by finding the hollow which exists where the horizontal and vertical portions of the joint meet and dividing the capsule. A transverse incision is made through the periosteum at the base of the malleolus at a slightly higher level than that selected for the osteotomy. A bone awl is then inserted at the tip of the malleolus and followed by a stainless steel screw. The screw is not driven quite home. It is then withdrawn so that the point is at a somewhat lower level than the horizontal plane of the joint. The



Fig. 12, 5



Fig. 12, 6

Osteoplastic approach to supramedial aspect talus. Medial malleolus has been divided and the screw used for retraction (Fig. 12, 5). At termination of operation, when screw is driven home, site of osteotomy cannot be detected (Fig. 12, 6). (H. G., female, aged 33. A13. Table VI. In the light of later experience preparation of both crater and fragment was inadequate.)

osteotomy using a very fine osteotome is then carried out in a more or less horizontal direction to enter the joint accurately at the junction of the vertical with the horizontal planes. The position of the tendon of tibialis posterior with the vessels and nerve is remembered in dividing the bone. Retraction of the malleolus is effected and an excellent view of the talus obtained by twisting a gauze swab round the head of the screw and exerting traction on the gauze. In this regard the under surface of the head of the screw selected

should be at right angles to the shaft and not bevelled in order that the twisted swab can obtain an adequate hold (Figs 12, 5 12, 6 and 7, 6 Figs 12, 7 and 12, 8)

LATERAL APPROACH

A straight incision is made over the fibula slightly anterior to the most prominent aspect. A small opening is made in the capsule immediately anterior to the fibula in order to locate the level of the inferior surface of the



Fig. 12, 7



Fig. 12, 8

Osteoplastic approach to the supramedial aspect of talus. Site of osteotomy of medial malleolus cannot be detected (Fig. 12, 7) Lesion has healed with slight loss of the normal contour (Fig. 12, 8). (H. S., male, aged 56, A5 Table VI.)

tibia A long oblique incision starting about the joint line is made in the periosteum of the fibula in a direction from before backwards and upwards. A horizontal hole is then drilled from before backwards through the fibula at the mid point of the incision and a self tapping screw inserted. The screw is withdrawn and with the aid of a Hey s or other small saw the cortex of the fibula is divided on the lateral aspect. The osteotomy is completed in a direction slightly oblique to the sagittal plane with a fine osteotome taking care not to splinter the bone. The division of the fibula in a direction oblique in two planes ensures that the lower fragment can be replaced without distortion of the original anatomy by either tilting or rotation and the long

opposing surfaces secured by internal fixation ensures union To complete the exposure the lower fragment together with the peroneal tendons are retracted backwards.





FIG 12, 9 FIG. 12, 10

Osteoplastic approach to supralateral aspect talus to show site of osteotomy and location of the screw (Figs. 12, 9 and 12, 10) Outline of bone element of fragment can still be detected (Fig. 12, 10) (J H., male aged 21 A4 Table VI)

LESION

The next step at either site is determined by the nature of the lesion In general, it will be found to be much more extensive than anticipated It bears no relationship to the radiological findings. The articular cartilage overlying a large clearly-defined fragment may be undamaged on the surface (Fig 12, 5) whereas an extensive cartilaginous injury involving half the diameter of the bone may overlie an apparently innocuous radiological lesion

1 **The loose body is quite free** —In these circumstances a decision must be made whether or not to attempt a repair In general the decision will rest on the size and site of the lesion the interval of time since separation and the difficulties involved in anatomical replacement. In the series three loose bodies only were found to be free In the first the lesion was small the loose body was discarded In the second also on the lateral aspect, separation had occurred some weeks previously and the loose body known to be upside down





Fig 12, 11 Fig 12, 12

Lesion on supralateral aspect of talus with loose body lying upside down at site (Fig. 12, 11). Fragment returned to crater and secured with nail (Fig. 12, 12) (J G male, aged 16, A12, Table VI)





Fig. 12, 13 Fig. 12, 14

Lesion in a recent osteoarticular fracture on supralateral aspect of talus. Fragment is upside down (Fig. 12, 13) Bony element of fragment, secured by nail has been incorporated in parent bone (Fig. 12, 14) (M S., female, aged 23 A16, Table VI)

(Fig. 12, 11) At operation the defect was of such dimensions that repair was essential to the future function of the joint At the termination of pre paratory measures the reduction was found to be unstable and there was no alternative, if the object of the operation was to be achieved to the use of internal fixation in the knowledge that the nail could not be recovered The risk of unfavourable reaction was thought to be small by comparison with the possible gain The result (A12) even on a short term basis appears to have



FIG. 12, 15



FIG. 12, 16

Recent osteoarticular fracture on supralateral aspect of talus comparable with Fig. 12, 12 (Fig. 12, 15) Fragment replaced and secured by nail giving radiograph comparable with Fig. 12, 14 (Fig. 12, 16). (This case a recent fracture is not included in Table VI nor mentioned in the text.)

justified the apparently radical decision (Figs 12, 11 and 12, 12) This case increased the confidence with which internal fixation was employed when a similar probable osteoarticular fracture was encountered (Figs. 12, 13 and 12, 14 see also Figs. 12, 15 and 12, 16)

2. **The loose body is attached by an isthmus of articular cartilage.**—In an extensive lesion the intact cartilage situated on the superior surface may not be visible Care is necessary in lifting up the flap of bone and cartilage to gain access to the crater lest the point of fixation be damaged and stability lost The sclerotic bone in the base of the crater will be found to be un believably hard only the most thorough preparation can achieve the blood supply which is essential for healing.

3 **The articular cartilage is intact**—In such circumstances less difficulty is likely to be encountered in locating the lesion in the ankle than in the knee

TABLE VI

Case No	Sex	Age	R or L	Site	Treatment	Result	Notes
A1	M	19	L	Lateral	Operation removal of fragment		
A2	F	30	R	Medial	Operation drilling	Clinical good Radiological healed	
A3	F	57	L	Medial	Operation arthrodesis	Arthrodesis in good position	Old lesion with gross arthritis
A4	M	21	L	Lateral	Operation drilling	Clinical excellent Radiological healed	
A5	M	56	L	Medial	Operation drilling	Clinical excellent Radiological healed with slight deformity	
A6	F	41	R	Medial	Observation		Operation not offered for psychiatric reasons
A7	F	33	R	Medial	Observation		Operation not offered for medical reasons
			L	Medial			
A8	M	26	R	Medial	Observation		Refused operation
A9	F	45	R	Medial	Operation drilling	Clinical good Radiological healed	
A10	F	34	R	Lateral	Operation removal of fragment		
A11	M	29	R	Medial	Operation drilling	Clinical excellent Radiological healed	
A12	M	16	R	Lateral	Operation drilling and internal fixation with nail	Clinical excellent	
A13	F	33	L	Medial	Operation drilling	Clinical excellent	Articular cartilage not fractured
A14	F	72	R	Medial	Observation		Lesion discovered following fracture of ankle
A15	M	26	R	Medial	Operation drilling	Clinical good	Five years history No injury other than constant football
A16	F	23	L	Lateral	Operation reduction and internal fixation with nail	Clinical excellent Radiological healed	Recent history of inversion sprain, single incident only Osteoarticular fracture rather than true osteochondritis dissecans

Loose bodies or lesions originating in fractures of the articular aspect of the medial or lateral malleolus have not been included.

joint. The site in the antero-posterior plane is known and pre-operative lateral tomographs, if necessary should have indicated the point in that plane In the single example of this situation in the series (case A13 Table VI) the site was identified as loose with the point of a blunt probe. The point of entrance for the dental probe or other penetrating instrument should be made on the medial (or lateral) aspect near the point where the planes meet rather than the superior weight-bearing surface If it is made at too low a level difficulty will be encountered in breaking up the bony element of the potential loose body

RESULTS OF TREATMENT

It is a question why in the ankle in particular difficulty has been encountered in attaining radiological union of the bony element of the fragment with the main mass of the bone Two possibilities arise (1) the blood supply is inadequate The nutrition of the body of the talus is notoriously poor The fragment to be revascularised is at the extreme periphery It may be that by comparison with the femur bony union is less likely to occur (2) preparation of both fragment and crater has been inadequate It is recognised that experience of operating on the lesion in the talus is limited. Insufficient perforation of the opposing bony elements of the ununited fracture combined with (1) above would entail the risk of failure of union.

There remains to be explained why in spite of failure to attain radiological union in some instances the patients concerned were rendered symptomless The ankle unlike the knee has not been re-explored It is only possible to interpret healing processes in terms of the experience gained in the knee joint. *It seems probable that, even if radiological union is not* obtained fixation of the articular cartilage and of the bony element by fibrous tissue is sufficiently sound to eliminate instability and the pain and giving way incidents which are so often the presenting symptoms.

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CHAPTER 13

HIP JOINT

CLINICAL **features**.—The disease is rare for reasons which have been described both as an entity and in comparison with other joints Most of the cases recorded have been young males but the age range varies widely between 6 and 62 One case in three is said to be bilateral.

There is no characteristic symptom or sign The presenting and dominating feature is pain Three stages of variable duration are generally recognised

1 *Latent*.—This stage is characteristic of osteochondritis dissecans in general and is that which exists between the occurrence of the fracture and the onset of recognisable symptoms That it occurs in the hip joint is shown by the existence of bilateral radiological lesions but with symptoms confined to one side (Lange 1929) This phase as in other joints may exist for many years

2 *Painful*.—This stage is characterised by the gradual onset of pain which may eventually attain a degree of severity which prevents weight-bearing in any form. In other respects the features are those of an early osteoarthritis. True locking does not occur In contrast with the knee and elbow the fragment does not separate completely and act like a free loose body The simple explanation is the ball and socket shape of the joint which does not permit the fragment to escape

3 *Arthritic*.—In the late stages of the disease the clinical features are indistinguishable from advanced osteoarthritis

RADIOGRAPHIC EXAMINATION

In the knee elbow and ankle joints the diagnosis can at least be suspected. In the hip with the exception of the rare case with a previous lesion in another joint (H3 Table VII) the radiographic findings will not have been anticipated. The typical osteochondritis dissecans lesion is located on the supralateral aspect of the femoral head Later as the head collapses and the disease progresses to the arthritic stage the typical appearance is lost and considerable difficulty may be encountered in determining the nature of the original pathology in a unilateral case

TABLE VII

Case No	Sex	Age	R or L	Treatment	Result	Notes
H1	M	33	R	Operation cup arthroplasty Later arthrodesis	Painless fixed hip	Both these joints might have been saved by the operation described
			L	Observation	Painful hip when last seen	
H2	F	18	L	Observation traction, immobilisation, etc. Finally operation arthrodesis (Charnley)	Painless fixed hip	This joint might have been saved by the operation described. Onset age 6
H3	F	19	R	Operation drilling and bone grafting	Healed clinically and radiologically Working as hospital nurse when last seen aged 23	Affection of R. hip and R. knee Fat girl with endocrine dys function (This is the case referred to in the text)
H4	F	62	L	Conservative traction, immobilisation	Unsatisfactory continued to have pain, will come to arthrodesis	It was an error to treat this patient conservatively She should have been treated by the operative method described in the text despite her age
H5	M	31	R	Observation	Seriously disabled pain and stiffness in both joints	Osteochondritis dissecans affecting multiple joints, in this case, both hips, both elbows, one knee, two meta carpophalangeal and four metatarsophalangeal joints. Onset age 14
			L			

DIFFERENTIAL DIAGNOSIS

1 *Legg-Calvé Perthes disease*—Difficulty can arise only within the age range for this common condition say five to ten The majority of cases described has been over this age

2. *Aseptic necrosis*—This may affect the whole head or a segment in the weight bearing area There is usually a history of preceding injury of major degree such as dislocation Difficulty could arise in the recognition of the local variety The difference is of academic rather than practical interest.

3 *Infective arthritis*—In the later stage when collapse of the weight bearing area has occurred there is a certain similarity of appearance

4 *Tuberculosis*—This possible diagnosis must always be considered It was the erroneous provisional diagnosis in two of the cases in this small series

5 *Caisson disease*

TREATMENT

The condition is rare and experience of treatment limited. In the largest series reported (Guilleminet and Barbier 1957) the results of the various forms of therapy employed were not encouraging. In this even smaller series, with the exception of the single case to which constant reference will be made the results have been in keeping with those previously reported

The successful outcome of conservative surgery in the knee joint determined the positive approach to the problem which was pursued when the occasion arose The temptation to direct action in the manner described for the knee was resisted It is generally but by no means universally accepted that operative dislocation of the hip is undesirable. Since the technique of conservative surgery in osteochondritis dissecans was described (Smillie 1955 1956 1957) a case has been recorded in which the method was applied to the hip joint (Jenkins 1958)

The technique of conservative surgery employed in the hip observed the principle that the operative approach to a joint should not be productive of disability It has been made possible by the availability of instruments designed for the purpose of bone grafting in fractures of the neck of the femur (Fitzgerald 1946 1948)

It is not suggested that this treatment could be applied to all cases of osteochondritis dissecans of the hip The success of the operation on an idealistic level would naturally depend on the stage at which the case was encountered At an early stage before secondary degenerative changes have occurred, the result might reasonably be expected to be comparable with the case which will be described. At a later stage the only advantage to be gained in revascularisation of the dead tissue followed by union with the surrounding bone is the possible facilitation of a future procedure such as arthroplasty or arthrodesis.

INSTRUMENTS

The instruments used are those originally described by Fitzgerald for the treatment of fractures of the neck of the femur by nailing supplemented by chip grafting. The technique employed in the operation for which the instruments were designed consisted of placing two parallel guide wires in the neck of the femur and using the upper wire as the guide for the nail and the lower one to direct the chip graft gun.

Chip graft gun—This composite instrument resembles a trochar and cannula The trochar consists of a cannulated twist drill 11½ inches (292 1 cm) long and of 9/32 inches (7 1437 mm) diameter with a ¼ inch (6·35 mm)

fitting for brace or detachable cross handle (Fig 13, 1) The cannula into which the blunt-ended solid trochar or plunger fits (Fig 13, 2) is calibrated to five inches (127 cm) has a funnel or hopper set at an angle, and is constructed with a trephine end (Fig 13, 3)

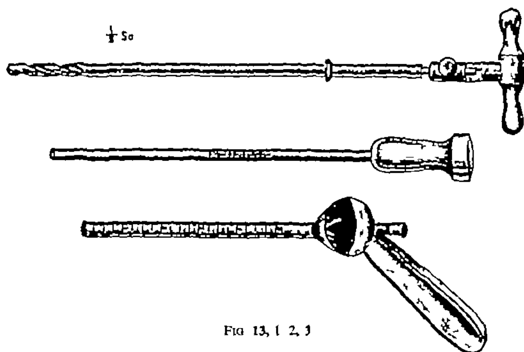


Fig 13, 1 2, 3

Fitzgerald's Instruments for placing Chip Bone Grafts in the Neck of the Femur

Fig. 13, 1 Cannulated twist drill with detachable cross handle Fig 13, 2. Blunt ended trochar or plunger Fig. 13, 3 Graduated cannula with hopper

TECHNIQUE OF OPERATION

The initial stages of the operation differ in no respect from those normally employed in the treatment of fractures of the neck of the femur The guide wire should enter the centre of the lesion and penetrate, but not perforate the fragment (Fig. 13, 4) The total depth of penetration from the outer cortex is recorded The twist drill is fitted into the cannula and threaded over the guide wire A hole is bored, determined in direction and depth by the guide wire, along the femoral neck to enter the bony element of the fragment (Fig. 13, 5) The drill is then withdrawn leaving the cannula in position (Fig 13, 6)

If the lesion is large the base of the crater can be broken up over a wider area and the prospects of revascularisation increased by passing four guide wires, one at each quadrant, down the outside of and parallel to the cannula

site in the right knee She was excessively heavy almost grossly so and was clearly the subject of hormonal derangement and/or an example of the dysostotic constitution. At operation in April 1955 a large fragment was replaced and secured with internal fixation. At the second operation four months later the lesion was seen to be healed and the nail removed Although she had regained movement rapidly to enable the second operation to be performed her progress in the return of flexion thereafter was slow This was attributed to her excessive weight in relation to her muscle power and she became the only example in the long series of knees in which a manipulation under anaesthesia was necessary to attain full flexion (She is the patient referred to on page 148) Her subsequent progress was excellent and she returned to hospital to resume her training

One year after the operation on her knee she reported complaining of pain in the hip on the same side The radiograph showed a lesion typical of osteochondritis dissecans of the hip (Fig 13, 8) In any event an error of diagnosis was impossible in view of the previous history The poor prognosis accorded to osteochondritis dissecans of the hip determined the decision to attempt to re-establish a blood supply to the bone element of the fragment by the technique described Even if the method had failed no material loss would have resulted Following the operation, performed in September 1956 she was allowed to exercise freely in bed Weight-bearing was permitted using crutches five months from the date of operation. The crutches were discarded three months later In this particular patient caution was exercised in allowing unrestricted weight bearing in view of her excessive weight.

She was last seen in March 1959 when it was not possible to detect any difference in range of movement or muscular development by comparison with the normal side. She had worked during the past year as a hospital nurse without symptoms Her radiograph showed that the lesion had disappeared completely The texture of the bone was abnormal but the contour of the head had been retained in both antero-posterior and lateral views (Figs. 13, 9 to 13, 11)

POSSIBLE APPLICATION OF PRINCIPLES OF TREATMENT TO PERTHES' DISEASE

It is not intended on this occasion to enter the controversial subject of the treatment of Perthes disease It is impossible however not to see in the facility with which the circulation can be restored to the metatarsal head in Freiberg s infraction and in the success of the operative technique employed in the only suitable case of osteochondritis dissecans of the head of the femur encountered a possible application of the principles involved to the treatment of Perthes disease

If it is accepted that the pathology of Freiberg s infraction and Perthes disease are the same then it would seem likely that the treatment applied to

the ischaemic metatarsal head with such success might apply also to Perthes disease. Unfortunately the diseases occur at different ages Destruction of the epiphyseal plate to establish a blood supply to the epiphysis at the various ages at which Perthes disease is encountered may not always be a practical proposition But it could be used in the early stages of a case occurring at a late age with the prospect as in Freiberg s infraction of rapid healing with minimum deformity of the head

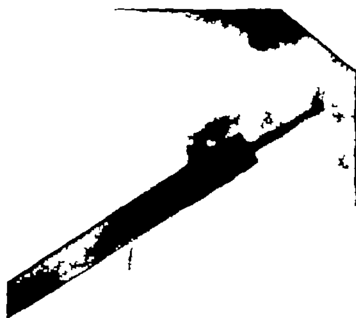


FIG 13 1.
Application of the method described in an attempt to revascularise epiphysis in Perthes disease (This is the same hip as Fig. 8 2. The final outcome of treatment is not yet known)

Surgical treatment of Perthes disease with the aim of more rapid revascularisation of the epiphysis than occurs by conservative methods has been described by various authors (Kidner 1916 Phemister 1921 Waldenström 1938 Levy and Girard 1942 Steele 1943 Howorth 1948 Pitzen 1951 Camargo 1957) The techniques employed include drilling curetting and bone-grafting procedures resulting in varying degrees of success or failure. It is suggested in the light of present knowledge that most of the cases subjected to operation would be far advanced pathologically as in Freiberg s infraction if the diagnosis was based on unmistakable radiological findings An operation based on the techniques which have been applied to Freiberg s infraction or to osteochondritis of the hip would only be justifiable in the earliest stages

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Fig 13, 12
Application of the method described in an attempt to revascularise epiphysis in Perthes disease (This is the same hip as Fig. 8 2 The final outcome of treatment is not yet known)

Surgical treatment of Perthes disease with the aim of more rapid revascularisation of the epiphysis than occurs by conservative methods has been described by various authors (Kidner 1916 Phemister 1921 Waldenström 1938 Levy and Girard 1942 Steele 1943 Howorth 1948 Pitzen 1951 Camargo 1957) The techniques employed include drilling curetting and bone-grafting procedures resulting in varying degrees of success or failure. It is suggested, in the light of present knowledge that most of the cases subjected to operation would be far advanced pathologically as in Freiberg s infraction if the diagnosis was based on unmistakable radiological findings An operation based on the techniques which have been applied to Freiberg s infraction or to osteochondritis of the hip would only be justifiable in the earliest stages





FIG. 13, 8 FIG. 13, 9

Operating Treatment of Osteochondritis Dissecans of Hip

FIG. 13, 8 Pre-operative tomograph to show site and extent of lesion. FIG. 13, 9 Immediate post-operation radiograph showing channel in bone and bone chips in tunnel (lateral quarter of tunnel contained no chips in order to give basis for comparison.)





FIG. 13, 10 FIG. 13, 11

Operating Treatment of Osteochondritis Dissecans of Hip

FIG. 13, 10 Radiograph one year from operation. Bone chips have been incorporated in the site of lesion revascularised. FIG. 13, 11 Radiograph two and a half years from operation. It is not a perfect joint, but it is comparable with normal. (E. R. female, aged 19. H3. Table VII.)

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of the disease and while the head retained the normal shape and in the complete absence of fractures superimposed on the ischaemic bone.

A method, similar in technique to that described for osteochondritis dissecans of the hip has been used by Camargo (1957) He removes with a trephine a cylinder of bone of as large a diameter as possible from the neck of the femur up to the epiphyseal line When the bone cylinder is returned to the tunnel the outer end is placed inwards The essential difference between this technique and that suggested is that Camargo makes a point of not damaging the epiphyseal plate. It would thus appear that the operation could do no more than act as an indirect stimulus to the revascularisation of the epiphysis. If the experience of the treatment of Freiberg s infraction can be applied to the treatment of Perthes disease, which seems of similar pathology it is essential that the barrier to revascularisation, namely the epiphyseal plate, be perforated

In so far as Perthes disease is concerned these suggestions are not intended to be more than exploratory statements based on the outcome of the study of the pathological anatomy of osteochondritis dissecans in general and of Freiberg s infraction in particular But there is no doubt that if the principles underlying the treatment of osteochondritis dissecans of the knee and hip and of Freiberg s infraction of the metatarsal head could be applied to Perthes disease a singular advance would be possible in the treatment of a most disabling complaint.

The method has been reserved and so far applied to one patient only the second hip of a bilateral example in which the first was grossly deformed. The outcome of operation could not possibly be worse than that obtained by conservative measures It is awaited with interest (Fig. 13, 12)

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